NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

67TH MEETING OF THE SENATE

TO BE HELD ON
TUESDAY, SEPTEMBER 20, 2022
FROM 03:00 P.M. ONWARD
AT THE SENATE ROOM, S.N. RAY MEMORIAL BUILDING
NIT DURGAPUR

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NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

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AGENDA NOTES

Item No. 67.1 Confirmation of the Minutes of the 66th. Senate Meetings.

The 66th Meeting of the Senate was held on April 13, 2022 at 10:30 AM in the Senate Room, S. N. Ray Memorial Building. The minutes of the said meeting were mailed to all Senate members for their comments **(Annexure 67.1.1)**. Several comments were received from the members on item no. 66.15.

Submitted to the Senate for discussion and the confirmation of the Minutes.

Item No. 67.2 Actions Taken Report

Reference Item No.	**Agenda Item**	**Action Taken on the Resolution**
66.2	To consider the equivalence of patent filing with one publication in an SCI/SSCI/AHCI/Non-paid Scopus/Web of Science Journal.	The alternatives proposed by the Committee constituted by the Senate may be discussed in the 67th Meeting of the Senate as Agenda Item # 67.6.
66.3	To consider the resolutions of UGAC meetings.	Resolutions duly implemented.
66.4	To consider the resolutions of PGAC meetings.	Resolutions duly implemented.
66.5	To consider the resolutions of RAC meetings.	Resolutions duly implemented.
66.6	To consider revision in Clause 13.7 of the PhD regulations in respect of uploading the full text of PhD thesis in INFLIBNET.	Action in progress.
66.7	To consider a change in the specialization name of the existing M. Tech. program offered by the department of ECE from "Telecommunication Engineering" to "Next Generation Communication and Networks".	Resolutions duly implemented.
66.8	To consider the modalities for starting self-financed M. Tech. programs from AY 2022-23.	Action in progress.
66.9	To consider the modalities for starting self-financed MBA program from AY 2022-23.	Action in progress.
66.10	To consider offering the M. Tech. program in Operations Research jointly by three departments.	Resolutions duly implemented.
66.11	To consider the Fee Structure for the AY 2022-23.	Revision in the fee structure for AY 2022-23 duly implemented. Work initiated on further revision in the fee structure.

66.12	To consider revision in the mode and weightage of the end-term examination (even semester, 2021-22) for the UG and PG students.	Resolutions duly implemented.
66.13	To consider issues related to possible placement of students from Bangladesh through the Career Development Centre of the Institute.	Action in progress.
66.14	To consider the framework proposed by the Chairman, Continuing Education Centre in regard to internship at NIT Durgapur.	Resolution duly implemented.
66.15	To consider issues related to the removal of gender bias through suitable change in the Institute motto as displayed in the Institute logo.	Action in progress.
66.16	To consider constituting an Advisory Committee for monitoring the smooth running of activities of the SRCC.	Resolutions duly implemented.
66.17.1	To consider the recommendations of the MoU Committee meeting held on 14.04.2022.	Action in progress. The resolutions on Research Methodology duly implemented.

PART A: MATTERS RELATED TO UG STUDIES

Item No. 67.3 To consider the resolutions of UGAC meetings

The Senate may consider the resolutions of UGAC meetings held on 31.05.2022, 29.07.2022 and 31.08.2022. **(Annexures 67.3.1, 67.3.2, 67.3.3)**.

PART B: MATTERS RELATED TO PG STUDIES

Item No. 67.4 To consider the resolutions of PGAC meetings

The Senate may consider the resolutions of PGAC meetings held on 31.05.2022, 29.07.2022 and 31.08.2022. **(Annexures 67.3.1, 67.3.2, 67.3.3)**.

PART C: MATTERS RELATED TO PhD STUDIES

Item No. 67.5 To consider the resolutions of RAC meetings

The Senate may consider the resolutions of RAC meetings held on 08.06.2022 and 07.09.2022 **(Annexures 67.5.1 and 67.5.2)**.

Item No. 67.6 To consider the alternatives proposed by the committee constituted by the Senate to consider the equivalence of patent filing with one publication in an SCI/SSCI/AHCI/Non-paid Scopus/Web of Science Journal.

The Senate may consider the alternatives proposed by the committee constituted by the Senate to consider the equivalence of patent filing with one publication in an SCI/SSCI/AHCI/Non-paid Scopus/Web of Science Journal resolutions of UGAC meetings. **(Annexure 67.6)**.

PART D: ACADEMIC MATTERS REQUIRING THE APPROVAL OF THE BOG

Item No. 67.7 To discuss issues pertaining to the 18th Convocation

The Senate approved via circulation the proposed conduction of the 18th Convocation of the National Institute of Technology Durgapur on Saturday, October 22, 2022 and noted with great honour and pride the confirmation regarding the presence of Shri Dharmendra Pradhan, Hon'ble Minister of Education and Minister of Skill Development & Entrepreneurship, Government of India, as the Chief Guest of the 18th Convocation of the Institute.

The Senate may approve the list of degree recipients and the gold medal awardees in the 18th Convocation (**Annexures 67.7**).

The Senate may discuss various other issues pertaining to the 18th Convocation.

PART E: OTHER MATTERS

Item No. 67.8 To consider signing MoUs with universities in India and abroad.

The Senate may consider signing MoU with Sister Nivedita University Kolkata and Vilnius Gediminas Technical University, Lithuania. (**Annexures 67.8.1 and 67.8.2**).

Item No. 67.9 To consider revision in the SRCC rules & regulations

The Senate may consider revision in the existing SRCC rules and regulations to facilitate the SRCC activities. (**Annexure 67.9**).

Item No. 67.10 Any other matter with the permission of the Chair.

Date: **Registrar & Secretary, Senate, NIT Durgapur**

ANNEXURE 67.1.1

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

66th MEETING OF THE SENATE

HELD ON
TUESDAY, APRIL 19, 2022
FROM 10.30 A.M. ONWARD
AT THE SENATE ROOM, S.N. RAY MEMORIAL BUILDING
NIT DURGAPUR

MINUTES

The meeting was attended by the following members:

The meeting was attended by the following members:

1.	**Prof. Anupam Basu** Director & Chairman-Senate NIT Durgapur	:	Chairman
2.	**Prof. S. Chattopadhyay** Department of Biotechnology, NIT Durgapur	:	Member
3.	**Prof. K. Aikat** Department of Biotechnology, NIT Durgapur	:	Member
4.	**Prof. (Ms.) Surabhi Chaudhuri** Department of Biotechnology, NIT Durgapur	:	Member
5.	**Dr. Debjani Dutta** **HoD**, Department of Biotechnology, NIT Durgapur	:	Member
6.	**Prof. S. S. Mukhopadhyay** Department of Biotechnology, NIT Durgapur	:	Member
7.	**Prof. D. Sukul** Department of Chemistry, NIT Durgapur	:	Member
8.	**Prof. A.K. Patra** Department of Chemistry, NIT Durgapur	:	Member
9.	**Prof. M. Maji** Department of Chemistry, NIT Durgapur	:	Member
10.	**Prof. Rajnarayan Saha** Department of Chemistry, NIT Durgapur	:	Member
11.	**Prof. Sankar Ch. Moi** Department of Chemistry, NIT Durgapur	:	Member

12.	**Prof. P. Gupta** Department of Chemical Engineering, NIT Durgapur	:	Member
13.	**Prof. K. C. Ghanta** **Dean (R&C)** Department of Chemical Engineering, NIT Durgapur	:	Member
14.	**Prof. P. Pal** Department of Chemical Engineering, NIT Durgapur	:	Member
15.	**Prof. A. K. Sadhukhan** Department of Chemical Engineering, NIT Durgapur	:	Member
16.	**Prof. S. Dutta** Department of Chemical Engineering, NIT Durgapur	:	Member
17.	**Prof. Gopinath Halder** Department of Chemical Engineering, NIT Durgapur	:	Member
18.	**Prof. Tamal Mandal** Department of Chemical Engineering, NIT Durgapur	:	Member
19.	**Dr. Jaya Sikder** **HoD**, Department of Chemical Engineering, NIT Durgapur	:	Member
20.	**Prof. D.K. Singha Roy** Department of Civil Engineering, NIT Durgapur	:	Member
21.	**Prof. K. Bhattacharya** Department of Civil Engineering, NIT Durgapur	:	Member
22.	**Prof. S. Bhattacharyya** Department of Civil Engineering, NIT Durgapur	:	Member

23.	**Prof. A.K. Banik** Department of Civil Engineering, NIT Durgapur	:	Member
24.	**Prof. Amiya Kr Samanta** HoD, Department of Civil Engineering, NIT Durgapur	:	Member
25.	**Prof. A. Das** Department of Civil Engineering, NIT Durgapur	:	Member
26.	**Prof. (Mrs.) T. Pal** Dept. of Computer Science & Engg. NIT Durgapur	:	Member
27.	**Prof. D. Nandi** Dept. of Computer Science & Engg. NIT Durgapur	:	Member
28.	**Prof. Subrata Nandi** HoD, Dept. of Computer Science & Engg. NIT Durgapur	:	Member
29.	**Prof. (Mrs.) Suchismita Roy** **Dean (FW)** Dept. of Computer Science & Engg. NIT Durgapur	:	Member
30.	**Prof. Avijan Dutta** Dept. of Management Studies NIT Durgapur	:	Member
31.	**Prof. Mousumi Roy** Dept. of Management Studies NIT Durgapur	:	Member
32.	**Dr. Kaushik Mandal** **HoD,** Dept. of Management Studies NIT Durgapur	:	Member
33.	**Prof. A.K. Bhattacharjee** Dept. of Electronics & Communication Engineering NIT Durgapur	:	Member
34.	**Dr. Durbadal Mondal** **HoD,** Dept. of Electronics & Communication Engineering NIT Durgapur	:	Member

35. Prof. Rowdra Ghatak : Member
Dept. of Electronics & Communication Engineering
NIT Durgapur

36. Prof. R. Mahapatra : Member
Dean (SW)
Dept. of Electronics & Communication Engineering
NIT Durgapur

37. Prof. G.K. Mahanti : Member
Dept. of Electronics & Communication Engineering
NIT Durgapur

38. Prof. Ashis Kr. Mal : Member
Dept. of Electronics & Communication Engineering
NIT Durgapur

39. Prof. B. Maji : Member
Dept. of Electronics & Communication Engineering
NIT Durgapur

40. Prof. S.S. Thakur : Member
Dept. of Electrical Engineering
NIT Durgapur

41. Prof. N.K. Roy : Member
Dept. of Electrical Engineering
NIT Durgapur

42. Prof. S. N. Mahato : Member
HoD, Dept. of Electrical Engineering
NIT Durgapur

43. Prof. T. K. Saha : Member
Dept. of Electrical Engineering
NIT Durgapur

44. Prof. C. Koley : Member
Dept. of Electrical Engineering
NIT Durgapur

45. Prof. Parimal Acharjee : Member
Dept. of Electrical Engineering
NIT Durgapur

46. Prof. K. Adhikari : Member
HoD, Dept. of Earth &Environmental Studies
NIT Durgapur

47. Prof. P.P. Sengupta : Member
Dept. of Humanities and Social Sciences
NIT Durgapur

48.	**Dr. J. Banerjee** **HoD**, Dept. of Humanities and Social Sciences NIT Durgapur	:	Member
49.	**Dr. Lakshmi Kanta Dey,** **HOD**, Dept. of Mathematics NIT Durgapur	:	Member
50.	**Prof. S. Kar** Dept. of Mathematics NIT Durgapur	:	Member
51.	**Prof. (Mrs.) Seema Sarkar (Mondal)** Dept. of Mathematics NIT Durgapur	:	Member
52.	**Prof. B. Halder** Dept. of Mechanical Engineering NIT Durgapur	:	Member
53.	**Prof. N. B. Hui** **Dean (Academic Courses)** Dept. of Mechanical Engineering NIT Durgapur	:	Member
54.	**Prof. A. B. Puri** Dept. of Mechanical Engineering NIT Durgapur	:	Member
55.	**Prof. S. S. Roy** Dept. of Mechanical Engineering NIT Durgapur	:	Member
56.	**Prof. N. Banerjee** Dept. of Mechanical Engineering NIT Durgapur	:	Member
57.	**Prof. A. Layek** Dept. of Mechanical Engineering NIT Durgapur	:	Member
58.	**Prof. I. Basak** Dept. of Mechanical Engineering NIT Durgapur	:	Member
59.	**Dr. Sumit Mukhopadhyay** **HoD,** Dept. of Mechanical Engineering NIT Durgapur	:	Member
60.	**Dr. Supriya Bera** **HoD**, Dept. of MME NIT Durgapur	:	Member

61.	**Prof. P. Kumbhakar** **Dean (Academic Research)** Dept. of Physics NIT Durgapur	:	Member
62.	**Prof. A. K. Meikap** Dept. of Physics NIT Durgapur	:	Member
63.	**Dr. Sukadev Sahoo** **HoD,** Dept. of Physics NIT Durgapur	:	Member
64.	**Prof. Amit Kr. Chakraborty** Dept. of Physics NIT Durgapur	:	Member
65.	**Mr. Soumya Sen Sharma** Registrar NIT Durgapur	:	Secretary

Prof. Ajitava Raychaudhuri, Prof. Siddhartha Sen, Prof. (Mrs.) Swagata Dasgupta, Sri S. Chatterjee, Mr. B. Bhattacharya, Ms. Dipa Das, Mr. Manish Awasthi, Prof. Dalia Dasgupta Mandal, Prof. A. Dey, Prof. S. Saha, Prof. P. Ray, Prof. Subhrabrata Choudhury, Prof. S. Banerjee, Prof. Sumit Kundu, Prof. (Mrs.) Kajla Basu, Prof. A. N. Mullick, Prof. K. S. Ghosh and Prof. Joydeep Maity could not attend the meeting and were granted leave of absence.

The Chairman welcomed the Senate members to the meeting and requested Secretary, Senate to present the agenda of the 66th Senate meeting.

Item No. 66.1 **Confirmation of the Minutes of the 62nd., 63rd., 64th. and 65th. Senate Meetings.**

The minutes of the 62nd., 63rd., 64th. and 65th. meetings were confirmed by the Senate.

Item No. 66.2 **Action Taken Reports**

The Senate of the Institute noted the Action Taken Reports with satisfaction.
In regard to Item No. 62.9 (To consider equivalence of filing of a patent with one publication in a SCI/SSCI/AHCI/Non-paid Scopus/Web of Science journal), the following Committee was constituted for deliberating on the matter:

1. Professor Pathik Kumbhakar, Chairperson
2. Prof. Sudip Chattopadhyay, Member
3. Professor Parimal Pal, Member
4. Professor Tandra Pal, member
5. Professor Chiranjib Koley, Coordinator, IPR Committee, Convenor

The Committee shall submit its report to the Chairman of the Senate.

PART A: MATTERS RELATED TO UG STUDIES

Item No. 66.3 **To consider the resolutions of UGAC meetings.**

The Senate ratified the resolutions of UGAC meetings held on 11.01.2022, 31.01.2022, 01.03.2022 and 11.04.2022 with the following rider:

- 31.01.2022: Item #6 - The Senate resolved that joint projects will also be considered for selection of Best Project in the UG level. The following Assessment committee was constituted:

  Dean (Academic Research) – Chairman
  Dean (Students Welfare) – Member
  Dean (Academic Courses) - Member
  Members of Innovation and Incubation Cell (IIC) – Members
  Coordinator of IIC – Coordinator

- 01.03.2022: Item #3 - The Senate recommended the proposed Seat Matrix with a provision of 15% supernumerary seats for the foreign nationals in all Dual Degree and Integrated M. Sc. Programmes. The same for the B. Tech. programs are approved already.

  The Senate also resolved that in the selection process of ICCR, applicants shall be shortlisted based on their marks obtained in the 10th, 12th examinations / CGPA and the essay submitted by them. The essay shall be assessed by the faculty members of the departments of HSS and MS. Similarly, applicants through SII shall be selected based on their 10th and 12th marks / CGPA.

- 11/04/2022: Item No. # 2 – The Senate recommended awarding of B. Tech. degrees to three students, namely, Biswanath Bar (Roll No. 11/ME/118), Sibanto Dutta (Roll No. 11/ME/112), Plabon Roy (Roll No. 11/ME/82), who have satisfied their graduation requirements already in the 18th Convocation. Their certificates shall indicate the date of completion as June 2017, June 2018 and June 2018, respectively.

PART B: MATTERS RELATED TO PG STUDIES

Item No. 66.4 To consider the resolutions of PGAC meetings.

The Senate approved the resolutions of PGAC meetings held on 11.01.2022, 31.01.2022, 01.03.2022 and 11.04.2022 with the following riders:

- 11.01.2022: Item #6 - The Senate resolved to terminate the studentship of Soumya Ghosh, who was drawing salary from the State Bank of India and scholarship from the Institute concurrently. Dean (SW) shall issue a notice to the student to immediately refund to the Institute the scholarship amount he has received till date.

- 31.01.22: Item #5 - The Senate resolved that the total credit mentioned in the approved PG curriculum shall be treated as the minimum total credit for the graduation requirement (Clause 13.2 of the PG Regulations). A PG student may, however, take additional credit courses, subject to prior endorsement by the department, which will be included in her/his grade card.

  As a special case, Mr. Avinaba Topadar (Roll No: 21EC4110), has been permitted to undertake an additional course in the even semester 2021-22 as recommended by the DPAC and PGAC.

- 31.01.2022: Item #6 - The Senate resolved that joint projects may also be considered for selection of the Best PG Project. The Assessment committee that was constituted for the UG projects shall act as the Assessment Committee for PG Projects too.

- 01.03.2022: Item #3 - The Senate recommended the proposed Seat Matrix with a provision of 15% supernumerary seats for the foreign nationals in all M.Sc., MBA and MSW programmes. The same for the M. Tech. programs are approved already.

PART C: MATTERS RELATED TO PhD STUDIES

Item No. 66.5 To consider the resolutions of RAC meetings.

The Senate approved the resolutions of RAC meetings held on 14.12.2021, 27.01.2022 and 12.04.2022, including the recommendation of award of PhD degrees to 20 candidates **(Annexure I)** and the approval of the registration of 37 candidates for the PhD program **(Annexure II)** with the following riders:

- 14.12.2021: Item #6 – Release sought by a regular Institute PhD research scholar before the completion of the PhD program, and the refund of scholarship amount received till date, shall be guided by the PhD regulations, while that sought by other regular PhD research scholars, funded by an external funding agency, shall be guided by the regulations of the respective funding agency.

- 14.12.2021: Item #8 - The Senate resolved the following addendum in the clause 2.3.3 of the PhD regulations.
  "The Chairman of the Senate is empowered to decide on the appeal by a Professional PhD student for a partial relaxation in residential requirement in a very special case, only on the recommendations of the DSC and RAC."

- 14.12.2021: Item #8 - The Senate approved the discontinuation of Som Subhra Dutta, subject to the refund of scholarship he has received till date, if stipulated by the funding agency.

- 27.01.2022: Item #4 - The Senate permitted the respective DSC to conduct the pre-registration seminars of Rohan Jadhav (18BT1103), Parboti Golui (18CH1502) and Anuj Kumar Pandey (19EE1501) within 3 months. However, the DSC of Rohan Jadhav (18BT1103) and Parboti Golui (18CH1502) will apprise the Chairman, Senate of the impediments in the progress of their doctoral studies.

- 27.01.2022: Item # 11 - The Senate approved the proposed format of the PhD Provisional certificate **(Annexure - III)**.

- 27.01.2022: Item # 12 – The Senate advised the DSC, DRPC and RAC to submit a clear recommendation on further extension of the PhD tenure of Chinmayee Behera (Reg. No. NITD/PhD/ME/2017/00926) of ME department.

- 27.01.2022: Item # 15 – The Senate resolved that a PhD specialization certificate **(Annexure IV)** shall be issued by the Dean (Academic Research) to the candidates of the Department of Humanities and Social Sciences (HS), who were awarded PhD degree in the 17th Convocation on specific and clear recommendation by the respective DSC and endorsement by the RAC on the specialization of the candidate in PhD studies. However, there shall be no amendment in the PhD degree certificate.

- 12.04.2022: Item #4 – The Senate granted one-year extension in the registration period beyond what is permitted in the PhD regulations in the Academic Year 2022-2023 on specific recommendation of the respective DSC. It will be applicable for the registered candidates whose research was hampered by COVID-19.

- 12.04.2022: Item # 6 – The Senate permitted the conduction of Pre-registration seminar of Bikramjit Mukherjee (19ME1502) and Rajrup Saha (18EC1106) within July 2022.

- 12.04.2022: Item # 11 – The Senate resolved that all the PhD-related seminars (other than the ones already scheduled) shall henceforth be conducted in offline mode except the PhD defence seminar which may be conducted either in online or offline mode, depending on the availability and convenience of the external examiner.

- 12.04.2022 Item # 12 – The Senate approved the proposed amendments in the PhD regulations with respect to clauses 1.1, 2.4.3.3 and 6.2.2.

- The discontinuation of the following 7 students from the PhD programme was approved by the Senate.

  (i) Suvashree Mukherjee (19CR1101) (ii) Somsubhra Dutta (19 BT1111, UGC Fellow), (iii) Putul Gorai (21EC1102), (iv) Ranashree Das (16ME1105), (v) Anita Barman (21MA1105), (vi) Amrita Gorai (14/ECE/1507) and (vii) Santanu Mondal (21BT1107)

Item No. 66.6 To consider revision in cl. 13.7 of the PhD regulations in respect of uploading the full text of PhD thesis in INFLIBNET

The Senate resolved to follow the instructions of the Ministry of Education as outlined in its communication F.No.31-10/2021-TS II for uploading of full text of the PhD theses in the Sodhganga repository immediately after the approval of the award of PhD degree. The clause 13.7 in the PhD regulations shall be amended as:

"13.7. The Institute shall submit the soft copy of the thesis to the INFLIBNET after the approval of the award of the PhD degree".

PART D: ACADEMIC MATTERS REQUIRING THE APPROVAL OF THE BOG

Item No. 66.7 To consider a change in the specialization name of the existing M. Tech. program offered by the department of ECE from "Telecommunication Engineering" to "Next Generation Communication and Networks".

The Senate recommended the proposed change in the specialization name of the existing M. Tech. program offered by the department of ECE from "Telecommunication Engineering" to "Next Generation Communication and Networks" with effect from AY 2022-23. Minor changes in the proposed curriculum, prepared in association with external experts, shall be incorporated by the DPAC of the Department of Electronics & Communication Engineering. The Chairman, Senate was authorized by the Senate to approve the revised curriculum, which, along with the eligibility criteria and the seat matrix shall be placed for consideration by the Board of Governors in its next meeting.

The Senate also recommended that the proposal submitted for NBA accreditation of the existing M. Tech. programme in Telecommunication Engineering be withdrawn.

Item No. 66.8 To consider the modalities for starting self-financed M. Tech. programs from AY 2022-23.

The Senate opined that comprehensive and structured proposals should be prepared by the willing departments in a common format, indicating the curriculum, syllabus, eligibility criteria for admission, seat matrix, content delivery and evaluation methods, tuition fee, etc. The Senate advised the proposing departments to interact with each other and ensure that the proposals are placed in the next meeting of the Senate through proper channel.

Item No. 66.9 To consider the modalities for starting self-financed MBA program from AY 2022-23.

The Senate advised the department of MS to interact with the departments willing to offer self-sponsored M. Tech. programs, revise their proposal and ensure that it is placed in the next meeting of the Senate through proper channel.
The Senate also resolved that separate degree nomenclature of the self-sponsored programs should be chosen to differentiate these from the regular academic programs offered by the Institute.

Item No. 66.10 To consider offering the M. Tech. program in Operations Research jointly by three departments.

The Senate recommended the proposal of offering M. Tech Programme in Operations Research jointly by three departments – Mathematics, Management Studies and Computer Science & Engineering with effect from AY 2022-23. The exiting M. Tech. program in Operations Research offered by the Dept. of Mathematics alone shall no longer be offered from AY 2022-23. The Senate also approved the eligibility criteria, revised curriculum and syllabus of the programme prepared in association with external experts and recommended by the PGAC.

The recommendations of the Senate shall be placed in the next meeting of the Board of Governors for due approval.

Item No. 66.11 To consider the Fee Structure for the AY 2022-23.

The Senate recommended the revised Fee structure (**Annexure V**) for the admission year 2022-23 for the UG, PG and PhD students, and recommended the withdrawal of the concessions given to the existing students due to COVID 19. The recommendations of the Senate shall be placed in the next meeting of the Finance Committee for due approval.
The Senate further constituted the following Committee for conducting a comparative study including all NITs and IIEST Shibpur and proposing revised user charges in the Fee Structure for the students.

- Prof. P.P. Sengupta, Professor, Department of Humanities & Social Sciences, Chairman
- Dr. Gautam Banerjee, CMA, Associate Professor, Department of Management, Member
- Dr. Anupam De, CA, Associate Professor, Department of Management, Member
- Dr. Siddhakam Bhattacharya, CMA, External Member.

PART E: OTHER MATTERS

Item No. 66.12 To consider revision in the mode and weightage of the end-term examination (even semester, 2021-22) for the UG and PG students.

The Senate ratified the resolutions taken in the meeting of the HODs and Deans with the Chairman, Senate on 31/03/2022 for revision in the mode and weightage of the end-term examination (even semester, 2021-22) based on the resolution of a meeting held between the Deans and the student's representatives on 30/03/2022. Students having back-log examination shall also be allowed to follow the revised mode and weightage as approved for the end-term examination, even semester 2021-22.
During the regular examinations, faculty members shall combine the CA3 and end-term marks components and submit under the end-term (out of 60 marks) through Chanakya software.
The Senate also resolved that the supplementary examinations (2021-22) shall be held offline and would carry 60 marks.

Item No. 66.13 To consider issues related to possible placement of students from Bangladesh through the Career Development Centre of the Institute.

The Senate recommended to consider the offer of internship and campus placement of the students from Bangladesh by the recruiters from Bangladesh through the Career Development Centre of NIT Durgapur. However, a-priori signing of MoU between the company and NIT Durgapur will be needed for the same.

The Senate also agreed in principle to the proposal of possible placement opportunities of foreign students from Bangladesh through the Career Development Centre of the Institute through a revisit of the extant norms.
In addition, the Senate resolved to revisit the existing norms for identifying any lacunae that might be in conflict with the extant norms.

Item No. 66.14 To consider the framework proposed by the Chairman, Continuing Education Centre in regard to internship at NIT Durgapur.

The Senate approved the proposal of the Chairman, Continuing Education Centre for reframing the resolution adopted in the 54th Meeting of the Senate in regard to internship at NIT Durgapur, and suggested a change in the fee for internship in NIT Durgapur as follows: Rs. 3000/- per month.

Item No. 66.15 To consider issues related to the removal of gender bias through suitable change in the Institute motto as displayed in the Institute logo.

The Senate resolved to organise a competition amongst the faculty, staff, student and alumni for selection of an appropriate motto.

Item No. 66.16 To consider constituting an Advisory Committee for monitoring the smooth running of activities of the SRCC.

The Senate approved the constitution of the following Advisory Committee for monitoring the smooth running of activities of the SRCC as proposed by the Dean (R&C).

1. Dean (Academic Research)
2. Dean (FW)
3. Prof. Ajit Kumar Meikap, Previous Dean (R&C)
4. Prof. Dipankar Sukul (CY) – Senate Nominee
5. Prof. Susmita Dutta (CH) – Senate Nominee
6. Dr. Aniruddha Chandra (EC) – Director's Nominee
7. Dr. Sayantari Ghosh (PH) - Director's Nominee

Item No. 66.17 Any other matter with the permission of the Chair.

66.17.1 To consider the recommendation of the MoU Committee meeting held on 14.04.2022

- The Senate recommended the signing of MoU between NIT Durgapur and Udyam Ventures Private Limited, New Delhi.
- The Senate also recommended the signing of MoU between NIT Durgapur and the Department of Metallurgical Engineering, Kazi Nazrul Univertsitty, Asansol after its recirculation amongst the possible stakeholders for increasing the scope of activities.
- The Senate also resolved that all MoU proposals should henceforth be routed through the HoD(s), Director and then the MoU Committee for placing it to the Senate for consideration.
- The Senate resolved that the Research Methodology course for the PhD students shall be conducted online though the end term examination would be conducted off-line.

The meeting ended with a vote of thanks to the Chair.

Soumyadeb Sharma

Registrar & Secretary, Senate
NIT Durgapur

Annexure-I

Award of PhD Degrees

SL. NO	REGN. NO	DEPT.	NAME OF THE SCHOLAR	NAME OF THE SUPERVISOR(S)	DATE OF AWARD
1	NITD/PhD/EC/2016/00818	EC	KAILASH PATI DUTTA	DR. G. K. MAHANTI	10.01.2022
2	NITD/PhD/CE/2017/00980	CE	SAYANTAN DUTTA	DR. R. P. NANDA	14.01.2022
3	NITD/PhD/BT/2015/00668	BT	PRADIP DAS	1) DR. A. BHATTACHARJEE 2) DR. S. S. MUKHOPADHYAY	12.01.2022
4	NITD/PhD/CE/2017/00880	CE	RAMIZ RAJA	DR. S. PAL	24.01.2022
5	NITD/PhD/ME/2018/01041	ME	MANISH KUMAR	1) DR. P. ROY 2) DR. K. KHAN	16.02.2022
6	NITD/PhD/BT/2018/01080	BT	TANMAY GHOSH	1) DR. K. AIKAT 2) DR. M. K. BISWAS, VISVA-BHARATI UNIVERSITY	21.02.2022
7	NITD/PhD/EE/2017/00994	EE	SOURABH KUNDU	DR. S. BANERJEE	25.02.2022
8	19RCH017	CH	ABHILASHA RAI	1) DR. S. DUTTA 2) DR. J. CHAKRABORTY	07.03.2022
9	NITD/PhD/MT/2015/00659	MM	SUJOY DAS	DR. M. M. GHOSH	08.03.2022
10	NITD/PHD/BT/2016/00762	BT	JYOTI RANJAN	DR. D. DASGUPTA MANDAL	11.03.2022
11	NITD/PhD/EC/2017/00936	EC	HARSHAVARDHAN SINGH	DR. S. K. MANDAL	17.03.2022
12	NITD/PhD/ECE/2014/00515	EC	SOMNATH PATRA	1)DR. S. K. MANDAL 2) DR. G. K. MAHANTI	17.03.2022
13	NITD/PhD/CH/2017/00992	CH	SHILPI CHATTERJEE	1) DR. K. C. GHANTA 2) DR. A. HENS	22.03.2022
14	NITD/PhD/CH/2016/00761	CH	UMA MAHESWARI R	DR. JAYA SIKDER	22.03.2022
15	NITD/PhD/MME/2016/00720	MM	SUVAM CHATTERJEE	1)DR. J. MAITY 2) DR. M. K. MONDAL	25.03.2022
16	NITD/PhD/MA/2017/00909	MA	SURAJIT KARMAKR	DR. L. K. DEY	29.03.2022
17	NITD/PhD/CE/2015/00678	CE	RAKTIM BISWAS	1)DR. S. PAL 2) DR. S. BHATTACHARYYA	01.04.2022
18	NITD/PhD/MME/2013/00438	MM	MOUSUMI MALLICK	1)DR. J. MAITY 2) DR. S. K. MAITRA 3) DR. D. BASAK, CSIR-CENTRAL INSTITUTE OF MINING & FUEL RESEARCH, DHANBAD	04.04.2022
19	NITD/PhD/CY/2018/001056	CY	AMITA MONDAL	1)DR. J CHAKRABARTY 2) DR. P. BANERJEE, CSIR-CMERI	06.04.2022
20	19REC036	EC	BITAN MISRA	DR. G. K. MAHANTI	08.04.2022

Annexure- II

Registration for the PhD program:

SL. NO	NAME	DEPT	SUPERVISOR	DATE OF REGISTRATION
RAC dt.14.12.2021				
1	SOUMYA MUKHERJEE	CE	DR. D. K. SINGHA ROY	08.09.2021
2	GOUTAM KUTI	CE	DR. S. KARMAKAR	12.11.2021
3	RAJIB KUMAR MONDAL	CS	DR. S. BHATTACHARJEE DR. T. PAL	12.11.2021
4	SANHITA SAHA	BT	DR.D.DUTTA	15.11.2021
5	POLURI SRI MANNARAYANA	EE	DR. A. DEY	17.11.2021
6	RAJEEV KUMAR	ME	DR. C. MISHRA DR. R. K. MITRA	17.11.2021
7	PAULAMI BANERJEE	CH	DR. R. GHOSH CHAUDHURI	01.12.2021
RAC dated 27.01.2022				
8	SHREERUPA BISWAS	EC	DR. S. RANWA	14.12.2021
9	RAHUL NAGA	BT	DR. S. SAHA	16.12.2021
10	NITESH KUMAR CHOUDHARY	ME	DR. S. KARMAKAR	20.12.2021
11	SIRSHENDU BANERJEE	CH	DR. B. KR. MONDAL DR. B. DAS	23.12.2021
12	ANAMIKA NAYAK	BT	DR. D. DUTTA	24.12.2021
13	CHOUHAN KUMAR RATH	CS	DR. A. SARKAR DR. A. K. MANDAL, SRM UNIVERSITY	28.12.2021
14	SUNANDA DAS	CS	DR. M. DALUI	28.12.2021
15	ARUNAVA CHATTERJEE	CH	DR. T. MANDAL	31.12.2021
16	KRISHANLAL ADHIKARI	EE	DR. N. K. ROY	05.01.2022
17	RAMAPATI PATRA	EC	DR. H. K. MONDAL	13.01.2022
18	BIJAY NARAYAN MOHANTY	ME	DR. A. LAYEK	20.01.2022
19	SUJIT KHANDAI	EE	DR. N. K. ROY	21.01.2022

RAC dated 12.04.2022				
20	KOYNDRIK BHATTACHARJEE	CE	DR. P. ROY	30.12.2021
21	BIKASH KUMAR SAW	EE	DR. A. K. BOHRE	10.01.2022
22	RANA DAS	EE	DR. I. AHMED	25.01.2022
23	DEBABRATA BEJ	EC	DR. N. CHATTARAJ	25.01.2022
24	PRASENJIT MAJI	EC	DR. H. K. MONDAL	10.02.2022
25	SOURAV ROY	CS	DR. B.SEN	28.02.2022
26	CHITRITA BANERJEE	CH	DR. G. HALDER DR. D. DATTA, GMR INSTITUTE OF TECH., RAJAM	28.02.2022
27	ANKITA DAWN	PH	DR. H. CHAUDHURI	07.03.2022
28	ARKA BANERJEE	ME	1) DR. S. SENGUPTA 2) DR. S. PRAMANIK	24.03.2022
29	PABITA MAHATO	MA	DR. S. SARKAR (MONDAL)	29.03.2022
30	SOURAV CHOWDHURY	MA	DR. P. P. GOPMANDAL	29.03.2022
31	SUSMITA SAMANTA	MA	DR. P. P. GOPMANDAL	29.03.2022
32	SNEHASHISH SARKAR	MA	DR. P. PAL	29.03.2022
33	SANGITA DUTTA	MA	DR. P. PAL	29.03.2022
34	SANTANU PANDA	HS	DR. S. K. RAI	04.04.2022
35	DEBASISH SUR	EE	1) DR. T. K. SAHA 2) DR. D. SINHA, DR. B. C. ROY ENGG. COLLEGE, DURGAPUR	04.04.2022
36	SUDHANGSHU SARKAR	EC	1) DR. A. CHANDRA 2) DR. A. DEY, NARULA INST. OF TECH. KOLKATA	06.04.2022
37	TITIKSHA DAS	HS	DR. D. CHAKRABORTY	08.04.2022

Annexure – II

ANNEXURE - III

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
MAHATMA GANDHI AVENUE, DURGAPUR-713209,
WEST BENGAL, INDIA

Ref. No:NITD/Dean(AR)/2022/PC/1 Date: DD.MM.2022

PROVISIONAL CERTIFICATE

(FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D.))

XXX XXXXX (Regn. No._______) has successfully defended the thesis titled "*aaaaaaaaaaaaaaaaaaaaaa*" on XX/ MM/ YYYY, fulfilling all the conditions stipulated by the Senate of this institute.

The degree will be conferred on the next Convocation of this Institute.

Dean (Academic Research)

The format has been recommended by the RAC in its meeting held on 27/01/2022.

This is placed for the approval by the competent authority.

R Kumar Sarkar 28/1/2022
(Dean (AR))

(DIRECTOR)
& Chairman (SENATE)

Telephone (Office): 0343 2752040/2752043 Fax: 0343 2547375 Website: www.nitdgp.ac.in

LETTER HEAD
OF ACADEMIC SECTION

Ref. No. Regn. No: DD.MM.YYYY

TO WHOM IT MAY CONCERN

This is to certify that **XXX C BANER** has carried out research work in the Department of Humanities & Social Sciences and has successfully defended the PhD thesis titled ***"Analysis of potential pacts of in BarjoHA-"* on 09.12.2022.** Accordingly, he/she has been awarded the degree "Doctor of Philosophy" by the Institute. The Doctoral Scrutiny Committee (DSC) of the candidate has recommended that the said work is in English/ Economics/ Management specialization.

This document is being issued upon request of the candidate.

Dean (Academic Research)

National Institute of Technology Durgapur

Annexure - V

(An Institute of National Importance under Ministry of Education, Govt. of India)

FEE STRUCTURE (B. Tech / Dual Degree / 5 Yr. Int. M. Sc) AY : 2022-23

Sl. No	Fee	1st semester (Amount in Rs.)		2nd to 8th (for B. Tech) / 2nd to 10th (for Dual Degree and 5 Yr Int. M. Sc) semesters (Amount for each semester in Rs.)	
		B. Tech / DD	Integrated M. Sc	B. Tech / DD	Integrated M. Sc
1	Admission fee	3000	3000	0	0
2	Institute Caution money (Refundable)	5000	5000	0	0
3	Hostel Caution Money (Refundable)	5000	5000	0	0
4	Institute Development Fee	10000	10000	0	0
5	Training and Placement Fee	3500	3500	0	0
6	Convocation Fee	500	500	0	0
7	Alumni Activity Fee	1000	1000	0	0
8	Institute Registration Fee	500	500	0	0
9	Tuition fee * #	62500	7500	62500	7500
10	Library charge	1000	1000	1000	1000
11	Computing Charge	3000	3000	3000	3000
12	Examinations Fees	1000	1000	1000	1000
13	Hostel seat Rent	5000	5000	5000	5000
14	Electricity and water charge	1500	1500	1500	1500
15	Maintenance Charge	1500	1500	1500	1500
16	Student Activity fund	1200	1200	1200	1200
17	Students Health Care	200	200	200	200
18	Comprehensive insurance premium including medical insurance	400	400	400	400
19	Hostel Establishment Charge	1200	1200	1200	1200
20	Employees welfare Fund	100	100	100	100
21	Student's Aid Fund	200	200	200	200
Total :		**107,300**	**52,300**	**78,800**	**23,800**

#

GOI, MEA-E (SAARC Countries) → USD 1750

GOI, MEA-E (Non SAARC Countries) →USD 3500

ICCR→USD 1500

DASA (Non SAARC Countries) →USD 4000

DASA (SAARC Countries) →USD 2000

DASA (CWIG)→INR 62500

SII →USD 1500

* **B. Tech/ DD:** For students of SC/ST/PH/Family income<1Lakh (Tuition fee is 100% waived). For students having family income between 1Lakh to 5 lakh per annum (Tuition fee is two third waives.)

* **Integrated M. Sc**: For SC/ST students, Tuition fee is 100% waived.

* Fee structure is subject to change under direction of the competent authority.

Dean (Academic Courses)

Date: 13/04/2022

National Institute of Technology Durgapur
(An Institute of National Importance under Ministry of Education, Govt. of India)

FEE STRUCTURE (2 Yr M. Sc, MSW, M. Tech, MBA) AY : 2022-23

Sl. No	Fee	1st semester (Amount in Rs.)			2nd to 4th semesters (Amount for each semester in Rs.)		
		2 Yr M. Sc / MSW	M. Tech	MBA	2 Yr M. Sc / MSW	M. Tech	MBA
1	Admission fee	3000	3000	3000	0	0	0
2	Institute Caution money (Refundable)	5000	5000	5000	0	0	0
3	Hostel Caution Money (Refundable)	5000	5000	5000	0	0	0
4	Institute Development Fee	5000	5000	5000	0	0	0
5	Training and Placement Fee	3500	3500	3500	0	0	0
6	Convocation Fee	500	500	500	0	0	0
7	Alumni Activity Fee	1000	1000	1000	0	0	0
8	Institute Registration Fee	500	500	500	0	0	0
9	Tuition fee* #	7500	35000	37500	7500	35000	37500
10	Library charge	1000	1000	1000	1000	1000	1000
11	Computing Charge	3000	3000	3000	3000	3000	3000
12	Examinations Fees	1000	1000	1000	1000	1000	1000
13	Hostel seat Rent	5000	5000	5000	5000	5000	5000
14	Electricity and water charge	1500	1500	1500	1500	1500	1500
15	Maintenance and Development Charge	1500	1500	1500	1500	1500	1500
16	Student Activity fund	1200	1200	1200	1200	1200	1200
17	Students Health Care	200	200	200	200	200	200
18	Comprehensive insurance premium including	400	400	400	400	400	400
19	Hostel Establishment Charge	1200	1200	1200	1200	1200	1200
20	Employees welfare Fund	100	100	100	100	100	100
21	Student's Aid Fund	200	200	200	200	200	200
Total :		**47,300**	**74,800**	**77,300**	**23,800**	**51,300**	**53,800**

#

GOI, MEA-E (SAARC Countries) → USD 1750

GOI, MEA-E (Non SAARC Countries) →USD 3500

ICCR→USD 1500

DASA (Non SAARC Countries) →USD 4000

DASA (SAARC Countries) →USD 2000

DASA (CWIG)→INR 62500

SII →USD 1500

***For SC/ST students (Tuition fee is 100% waived for M. Sc, MSW and MBA programme)**

Dean (Academic Courses)

Date: 13/04/2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

MAHATMA GANDHI AVENUE, DURGAPUR- 713 209

FEE STRUCTURE FOR THE ADMISSION YEAR OF 2022-2023

PhD PROGRAMME

A. PAYABLE AT THE TIME OF ADMISSION (ONE TIME PAYMENT)

ITEM	AMOUNT IN INR
Admission Fee	**3000**
Registration Fee	**5000**
Institute Development Fee	**5000**
Institute Caution Money	**15000**
Convocation Fee	**500**
TOTAL	**28500**

B. TUITION FEE (PAYABLE PER SEMESTER INCLUDING FIRST SEMESTER)

ITEM	AMOUNT
INDIAN SCHOLARS- Category A, B, C, D and L	**INR 7500**
INDIAN SCHOLARS- Category G, H, I, J and K	**INR 20000**
FOREIGN SCHOLARS- GOI, MEA-E **(SAARC Countries)-** Category E	**USD 1500**
FOREIGN SCHOLARS-GOI, MEA-E **(non-SAARC Countries)-** Category E	**USD 3000**

C. OTHER INSTITUTE FEE (PAYABLE PER SEMESTER INCLUDING FIRST SEMESTER)

ITEM	AMOUNT IN INR
Library charge	**1000**
Computing charge	**3000**
Students' Health Care	**200**
Examination Fee	**1000**
Students Activity Fund	**1200**
Comprehensive Insurance premium including Medical Insurance (For Full Time scholars only)	**400**
TOTAL	**6800**

D. HOSTEL FEE (PAYABLE PER SEMESTER INCLUDING FIRST SEMESTER)

ITEM	AMOUNT IN INR
Seat Rent	**5000**
Electricity and Water Charge	**1500**
Hostel Employees' Welfare Fund	**100**
Students' Aid Fund	**200**
Maintenance and Development Charge	**1500**
TOTAL	**8300**

E. OTHER HOSTEL / MESS RELATED CHARGES

ITEM	AMOUNT IN INR
Hostel / Mess Caution Money (Onetime payment, refundable after adjustment)	**5000**
Hostel / Mess Establishment Charge (Payable each Semester)	**1200**
Mess advance (Payable each Semester)	**As applicable**

F. FEE PAYABLE AT THE TIME OF THESIS SUBMISSION

ITEM	AMOUNT IN INR
Thesis submission Fee (Onetime payment)	**15000**

RKumbhakar

DEAN (ACADEMIC RESEARCH)
15.04.2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Academic Section

Date: 31.05.2022

Minutes of the meeting of UGAC and PGAC held jointly at the meeting room of the academic section on 31.05.2022 (Tuesday) at 03.00 pm.

The Chairman welcomed the members to the meeting.
The agenda items were placed for discussion.

Item # 1 Confirmation of the minutes of UGAC and PGAC held on 11.04.2022.

The minutes of the UGAC and PGAC meeting held on 11.04.2022 were confirmed.

Item # 2 To consider ratification of provisionally published results of 1st Semester UG, 2021-22.

The provisionally published results of 1st Semester UG, 2021-22 is ratified. Also, corrigendum results is recommended for approval by the Senate.

The marks obtained under different sessional subjects of the students bearing Roll Nos. 21D80083, 21D80087 and 21F80086 are to be rechecked by concerned subject teachers.

Item # 3 To consider the publication of even semester regular / backlog results 2021-22 (other than first year UG).

The even semester 2021-22 regular, backlog results (other than first year UG) are recommended for approval and subsequent publication on public domain.

- No distinction will be awarded for the B. Tech and M. Tech Dual Degree program and Integrated M.Sc program.
- Due to a mistake in the assignment of credits to the subject CSC404 – Object Oriented Programming (results has been published with 2 credits, however, the subject is of 3 credits), modification of results in Semesters 4, 5, 6 and 7 were necessary for BTECH 8th semester students of AY 2021-22 and it is recommended by UGAC. All such students shall be issued revised grade cards.
- Results of 648 students of 4th semester under graduate program are kept withheld and will be subsequently published on 25.07.2022 upon receipt of clearance from the office of Chief Warden and / or Dean (Students Welfare) (Annexure I).

Item # 4 To consider the minutes of the meeting of Examination Disciplinary Committee held on 10.05.2022.

The minutes of the meeting of Examination Disciplinary Committee held on 10.05.2022 is recommended for approval.

Item # 5 To consider the matter regarding not appearing for end semester examination 2021-22 due to medical reasons.

- **Rajib Sarkar - Roll No. 19ME8045 - HSC631, MEE613, MEE625**
- **Shreya Lama - Roll No. 20CS8019 - CSC405, EEO440**

The students will be allowed to appear for supplementary examination 2021-22 under medical reasons (without deduction of grades).

hmi
Dean (Academic Courses)
National Institute of Technology
Durgapur-713209 India

Item # 6 **To consider the appeal on cancellation of admission –**

Sl No.	Reg. No.	Roll No.	Name	Programme / Department
1	20U10696	20F80070	RISHABH TA	B. TECH
2	20U10127	20CS8043	SUMAN DAS	B. TECH
3	21U10092	21B80010	ANKIT HOWLADAR	B. TECH
4	21U10339	21I80034	SOUGATA BOSE	B. TECH
5	19U10726	19MM8054	B. SAI VISHNU VARDHAN	B. TECH
6	20U10844	20CS8190	PRAMITA SAMANTA	B. TECH

The matter of withdrawal by the respective students are accepted. The Institute fee and Hostel fee paid by the candidates/students will not be refunded. Institute caution money, if any, may be refunded to the bank account of the individual students at the end of the current financial year.

However, no refund will be admissible to the candidates, who do not take admission to the Institute after final allotment of seats through centralized counselling such as CCMT, CCMN, CSAB, JoSAA, etc. Entire amount paid by such candidates during the counselling process and admission process will not be refunded.

Item # 7 **To consider the matter regarding correction of records on Chanakya portal.**

- Sudipto Swar (Roll No. 20ME8181) – Date of Birth to be corrected as 05/10/2000
- Niloy Deb (Roll No. 20CS8122) – Mothers surname to be corrected as Mojumder

The matter of correction may be incorporated in the Institute academic software.

Item # 8 **To consider the request regarding incorporation of NPTEL and UDEMY courses on the grade card of Pranjal Mittal (Roll No. 18EC8073).**

The matter is discussed in detail and decided that the entry of marks will be done from the end of the Department concerned.
Henceforth, all such cases (credit course as well as audit course) will be done in accordance with the provisions of the regulation related to credit transfer.

Item # 9 **To consider the matter regarding the minutes of DAC meeting of CH Department held on 29.04.2022 on**

- **Offering a new open elective for 5th semester UG students (Solid and Hazardous waste management with a holistic approach – CHO541).**
- **On assigning coordinator for Dual Degree program.**
- **Conduct of end semester examinations.**

The matter is discussed and it is decided that the syllabus will be endorsed by the Department and will be sent to the Dean (Academic Courses) by 30.06.2022.

hmi
Dean (Academic Courses)
National Institute of Technology
Durgapur-713209 India

Item # 10 **To consider the matter of conversion from M. Tech Regular mode to M. Tech Off campus mode after successful completion of the first year of the programme by Kotha Venkatesh (Roll No. 20CE4212 / Reg. No. 20P10242.**

The matter is recommended for approval and the scholarship are to be discontinued. However, there will be a modification in the application form where the date of joining to the organization is to be mentioned which has to be recommended and forwarded by the respective Head of the Department as applicable for termination of scholarship

Item # 11 **To consider the matter related to Best Project Awards (UG and PG).**

Sri Akash Manna (Roll No. 18CS8129) and Sri Sayantan Chatterjee (Roll No. 20EE4115) were selected respectively for best under graduate project award 2021-2022 and best post graduate project award 2021-2022 (refer to Annexure – II)

Item # 12 **To consider the Academic Calendar 2022-23.**

The matter is recommended for approval. (Annexure III)

Item # 13 **To consider the schedule of**

- **Supplementary / backlog examination for final year 2021-2022 and first year 2021-2022**
- **Alternative midterm examination for first year 2021-22**
- **Midterm examination of XXC01**

The matter is discussed and resolved that

- Supplementary / backlog examination for final year 2021-2022 and first year 2021-2022 will be held during June 13 – 17, 2022
- Alternative midterm examination for first year 2021-22 will be held during June 20 – 24, 2022
- Midterm examination of XXC01 will be held in offline mode as per the schedule (Annexure – IV)

The meeting ended with vote of thanks to the Chairman.

Dean (Academic Courses)
National Institute of Technology
Durgapur-713209 India

Dean (Academic Courses)
Date: 31.05.2022

Annexure - I

NIT
DURGAPUR

Dean Academic Courses <deanac@admin.nitdgp.ac.in>

Fwd: Request to withhold the result for 4th semester for all the boarders of Hall 14

Chief Warden NITD <chiefwarden@admin.nitdgp.ac.in> Fri, May 27, 2022 at 6:37 PM
To: Dean Academic Courses <deanac@admin.nitdgp.ac.in>
Cc: Dean Student Welfare <deansw@admin.nitdgp.ac.in>

Dear Sir
Please find the trailing email and find herewith the list of the non-depository students (arranged department-wise) of Hall-14.

Thanks and Regards
Manas

---------- Forwarded message ---------
From: **Anupam Basu (অনুপম বসু)** <anupambas@gmail.com>
Date: Fri, May 27, 2022 at 4:50 PM
Subject: Re: Request to withhold the result for 4th semester for all the boarders of Hall 14
To: Chief Warden NITD <chiefwarden@admin.nitdgp.ac.in>

Results should be withheld.

On Fri, 27 May, 2022, 1:30 pm Chief Warden NITD, <chiefwarden@admin.nitdgp.ac.in> wrote:

> Dear Sir
>
> This is to inform you that Warden(s) of Hall 14 has imposed a fine of Rs. 10,000/- to each border of Hall 14 for vandalism of hostel properties (fire extinguishers, breaking of door locks, hatch-bolt, and missing receivers and damaging of the lifts) via a notification dated 28/04/2022 (a copy of the notice is attached). As per the Warden(s) information, nobody (boarders of Hall 14) has deposited the fine amount. The list of the non-depository students is attached.
>
> Therefore, the fourth semester result may be withheld for the boarders of Hall 14 till the deposition of the fine amount.
>
> This is placed before for your kind approval.
>
> Thanks and regards
>
> Manas
>
> ---
> ---------- Forwarded message ---------
> From: **Chief Warden NITD** <chiefwarden@admin.nitdgp.ac.in>
> Date: Thu, May 26, 2022 at 6:01 PM
> Subject: Request to withhold the result for this semester for all the boarders of Hall 14
> To: Dean Academic Courses <deanac@admin.nitdgp.ac.in>
> Cc: Dean Student Welfare <deansw@admin.nitdgp.ac.in>, Registrar NIT Durgapur <registrar@admin.nitdgp.ac.in>, Director NIT Durgapur <director@admin.nitdgp.ac.in>, Anupam Basu <anupambas@gmail.com>
>
> Dear Sir
>
> This is to inform you that Warden(s) of Hall 14 has imposed a fine of Rs. 10,000/- to each border of Hall 14 for vandalism of hostel properties (fire extinguishers, breaking of door locks, hatch-bolt, and missing receivers and damaging of the lifts) via a notification dated 28/04/2022 (a copy of the notice is attached). As per the Warden(s) information, nobody (boarders of Hall 14) has deposited the fine amount. The list of the non-depository students is attached.
>
> Therefore, you are requested to withhold the result for this semester for all the boarders of Hall 14.
>
> Thanks and regards

Manas

--
____
Manas Kumar Mondal, Ph D
Associate Professor and Chief Warden
Department of Metallurgical & Materials Engineering
National Institute of Technology Durgapur, India

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____
Manas Kumar Mondal, Ph D
Associate Professor and Chief Warden
Department of Metallurgical & Materials Engineering
National Institute of Technology Durgapur, India

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____
Manas Kumar Mondal, Ph D
Associate Professor and Chief Warden
Department of Metallurgical & Materials Engineering
National Institute of Technology Durgapur, India

Non-depository students _List_Hall-14_27-05-2022.xlsx
31K

Annexure - II

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Academic Section

Date: 30.05.2022

Minutes of the meeting held on 28.04.2022 and 25.05.2022 for evaluation of best Undergraduate Project Award and best Postgraduate Project Award 2021-2022.

The meeting is chaired by Prof. P. Kumbhakar Dean (Academic Research) and attended by Prof. N. B. Hui, Dean (Academic Courses), Prof. K. C. Ghanta, Dean (R & C), Prof. R. Mahapatra, Dean (Students' Welfare), Dr. S. K. Lahiri, Department of Chemical Engineering, Dr. Sayantari Ghosh, Department of Physics, Dr. A. Goswami, Department of Mechanical Engineering and Dr. A. Bhattacharya, Department of Electrical Engineering.

1. The project of Sri. Akash Manna (Roll No.: 18CS8129) was selected for best Undergraduate project award 2021-2022 among ten entries from the department of Biotechnology (2), Civil Engineering (2), Chemical Engineering (1), Electronics and Communication Engineering (2), Mechanical Engineering (2) and Computer Science and Engineering (1).
2. The project of Sri. Sayantan Chatterjee (Roll No.: 20EE4115) was selected for best Postgraduate project award 2021-2022 among eight entries from the department of Civil Engineering (1), Chemical Engineering (1), Electronics and Communication Engineering (1), Mathematics (1), Electrical Engineering (2), Metallurgical and Materials Engineering (1) and Computer Science and Engineering (1).

The meeting ended with vote of thanks to the Chairman.

P. Kumbhakar 30/5/2022

Prof. P. Kumbhakar
Dean (Academic Research) & Chairman

Annexure - III

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

ACADEMIC CALENDAR - 2022-2023

	ODD SEMESTER										EVEN SEMESTER									
DAYS	AUG' 22		SEPT' 22		OCT' 22		NOV' 22		DEC' 22		JAN' 23		FEB' 23		MARCH' 23		APRIL' 23		MAY' 23	
SUN											1									
MON	1	CLASS BEGINS									2	CLASS BEGINS							1	
TUE	2						1				3								2	
WED	3						2				4		1		1				3	
THU	4		1				3		1		5		2		2				4	
FRI	5		2				4		2		6		3		3				5	Buddha Purnima
SAT	6		3		1		5		3		7		4		4		1		6	
SUN	7		4		2	Gandhi Birthday	6		4		8		5		5		2		7	
MON	8		5		3	Mahaasthami	7		5		9	Supp. Examination, Odd Sem 2022-23	6		6		3		8	
TUE	9	Muharram	6		4		8	Guru Nanak's Birthday	6		10		7		7		4		9	
WED	10	Supp. Exam, Even Sem. 2021-22	7		5	Dussehrra	9		7		11		8		8	Holi / Dolyatra	5		10	
THU	11		8		6		10		8		12		9		9		6		11	
FRI	12		9		7		11		9		13		10		10		7	Good Friday	12	
SAT	13		10		8		12		10		14		11		11		8		13	
SUN	14		11		9	Id-e-Milad	13		11		15		12		12		9		14	
MON	15	Independence Day	12		10		14		12		16		13		13		10		15	
TUE	16		13		11		15		13		17		14		14		11		16	
WED	17		14		12		16		14		18		15		15		12		17	
THU	18		15		13		17		15		19		16		16		13		18	
FRI	19	Janmasthami	16		14		18		16		20		17		17		14		19	
SAT	20		17		15		19		17		21		18		18		15		20	
SUN	21		18		16		20		18		22		19		19		16		21	
MON	22		19		17		21	END-TERM EXAM (THEORY)	19	* MARKS SUBMISSION	23		20	MID-TERM EXAM (THEORY)	20		17		22	# MARKS SUBMISSION
TUE	23		20		18		22		20		24		21		21		18		23	
WED	24		21		19		23		21		25		22		22		19		24	
THU	25		22		20		24		22		26	Republic Day	23		23		20		25	
FRI	26		23		21		25		23		27		24		24		21		26	
SAT	27		24		22		26		24		28		25		25		22	Idul-Fitr	27	
SUN	28		25		23		27		25	Chirstmas Day	29		26		26		23		28	
MON	29		26	MID-TERM EXAM (THEORY)	24	Diwali	28		26		30		27		27		24	END-TERM EXAM (THEORY)	29	
TUE	30	Pub. of Supp. Result, Even Sem, 2021-22	27		25		29		27	Pub. of Result, Odd Sem, 2022-23	31	Pub. of Supp. Result, Odd Sem, 2022-23	28		28		25		30	Pub. of Result, Even Sem, 2022-23
WED	31		28		26		30		28						29		26		31	
THU			29		27				29						30		27			
FRI			30		28				30						31		28			
SAT					29				31								29			
SUN					30												30			
MON					31															

Festival Break (Students, Faculty): October 04 - 07, 2022

Winter Break (Students): December 01 - 31, 2022

Winter Break (Faculty): December 20 - 30, 2022

Summer Break (Students): May 01 - July 16, 2023

Summer Break (Faculty): May 25 - July 07, 2023

* Last date of Odd Semester Marks submission by the teachers in Chanakya Software

Last date of Even Semester Marks submission by the teachers in Chanakya Software

Academic Year 2023-24 begins : July 17, 2022

Sd/-
Dean (Academic Courses)

Date: 31/05/2022

NIT
DURGAPUR

Dean Academic Courses <deanac@admin.nitdgp.ac.in>

Resolution in the DAC held on 30/05/2022 in relation to Mid term of the Course "Constitution and Civic Norms"

1 message

HOD DMS <hod@dms.nitdgp.ac.in> Mon, May 30, 2022 at 6:32 PM
To: Dean Academic Courses <deanac@admin.nitdgp.ac.in>
Cc: Avijan Dutta <avijan.dutta@dms.nitdgp.ac.in>, Mousumi Roy <mousumi.roy@dms.nitdgp.ac.in>, Gautam Bandyopadhyay <gautam.bandyopadhyay@dms.nitdgp.ac.in>, Neelotpaul Banerjee <neelotpaul.banerjee@dms.nitdgp.ac.in>, Anupam De <anupam.de@dms.nitdgp.ac.in>, Amlan Ghosh <amlan.ghosh@dms.nitdgp.ac.in>, "Mr. Subhadip Sarkar" <subhadip.sarkar@dms.nitdgp.ac.in>, Ujjwal Kanti Paul <ujjwalkanti.paul@dms.nitdgp.ac.in>, Kaushik Mandal <kaushik.mandal@dms.nitdgp.ac.in>

Prof. N B Hui
Dean Academic Courses
NIT Durgapur

Respected Prof Hui

Today in a DAC meeting DAC DMS has unanimously agreed with the communication of Dr. M Islam, invited faculty member of this course and has decided
i) mid term of the Course "Constitution and Civic Norms" will be of 10 multiple question answer types and each question will be of 2.5 marks each.
ii) duration of the examination would be of 30 minutes.

This above resolution is for your kind consideration and requisite approval from appropriate authorities

Thanking you
HOD DMS

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Academic Section

Date: 29.07.2022

Minutes of the meeting of UGAC and PGAC held jointly at the meeting room of the academic section on 29.07.2022 (Friday) at 03.00 pm.

The Chairman welcomed the members to the meeting.
The agenda items were placed for discussion.

Item # 1 **Confirmation of the minutes of UGAC and PGAC held on 31.05.2022.**

The minutes of the UGAC and PGAC meeting held on 31.05.2022 were confirmed.

Item # 2 **To consider the publication of**

a. **Final Year UG supplementary / special back-log examination 2021-22**
b. **1st semester UG supplementary examination 2021-22**
c. **2nd semester regular examination 2021 - 2022**

The results are recommended for approval and subsequent publication on public domain.

Md. Aman Alam (Roll No. 21E80025) was Reported Against for adopting unfair means in "Constitution of India and Civic Norms" (XXC01) and the matter will be dealt in accordance with the existing norms / provisions of the regulations of UG program.

Supplementary examination 2021-2022 will be held from 08th August 2022.

Item # 3 **To consider the list of Degree recipients and Gold medal recipients of B.Tech programme (706 + 04 of previous years), B.Tech and M.Tech Dual Degree programme (08), Integrated M.Sc programme (08), M.Tech programme (281). M.Sc programme (88), MBA programme (29) and MSW programme (02) to be awarded in 18th Convocation.**

The list is prepared and presented to the Senate for recommendation. (Annexure I)

Item # 4 **To consider the appeal on cancellation of admission –**

Sl No.	Reg. No.	Roll No.	Name	Programme
1	21P10374	21EE4218	MD SHARFUDDIN	M. TECH
2	20U10750	20BT1006	ADITYA CHOWDHURY	DUAL DEGREE

The matter of withdrawal by the respective students are accepted. The Institute fee and Hostel fee paid by the candidates/students will not be refunded. Institute caution money, if any, may be refunded to the bank account of the individual students after the current financial year.

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Durgapur-713209 India

However, no refund will be admissible to the candidates, who do not take admission to the Institute after final allotment of seats through centralized counselling such as CCMT, CCMN, CSAB, JoSAA, etc. Entire amount paid by such candidates during the counselling process and admission process will not be refunded.

Item # 5 **To consider the matter regarding correction of name (to be corrected as Kinnera Harshitha Sanjivini) of Kinnera Harshitha Sanjivini (Reg. No. 21U10551) in Chanakya portal.**

The matter of correction may be incorporated in the Institute academic software.

Item # 6 **To consider modified curricula of B. Tech minor Marketing Management.**

The matter is discussed in detail and the modified curricula of B. Tech minor Marketing Management is recommended for approval (Annexure II)

Minor in Marketing Management						
Semester	**Name of the subject**		**L**	**T**	**P**	**Credits**
Sem V	Marketing Management		3	0	0	3
	Marketing Lab-I		0	0	2	1
Sem VI	Research Methodology		3	0	0	3
	Marketing Lab-I		0	0	2	1
Sem VII	Digital Marketing	Any Two	3	0	0	3
	Marketing Research		3	0	0	3
	Marketing Communication		3	0	0	3
	Consumer Behaviour		3	0	0	3
Sem VIII	Marketing Analytics	Any Two	3	0	0	3
	Sales and Distribution Management		3	0	0	3
	Service Marketing and Retail management		3	0	0	3
					Total	20

Item # 7 **To consider the matter of establishing "Non-formal Sanskrit Education Center of Central Sanskrit University".**

The matter is discussed in detail and resolved that a centre may be started in the Institute. Department of HSS will be coordinating department. Space for the centre will be allocated by the Institute.

Item # 8 **To consider the matter regarding Project Evaluation of M. Tech 2nd year students of EE Department undergoing one year internship in the industry.**

The matter is discussed and decided that detail deliberations are to be taken up at the departmental level after which the views of the departments will be placed in the next meeting of PGAC.

Item # 9 **To consider the matter on advising the students to visit Atal Tunnel, Rohtang and understand the best practices in engineering, design, planning, construction and project management.**

The Department of Civil Engineering and the office of Dean (Students Welfare) will take necessary initiative for the visit of students in batches to the Atal Tunnel, Rohtang and understand the best practices in engineering, design, planning, construction and project management.

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For the first time, HOD, Dept. of Civil Engineering shall submit 10 students (UG, PG combined) to the office of Dean (Academic Courses) for recommendation and onward processing.

Item # 10 **To consider the matter on appearing the 2nd semester supplementary examination 2021-2022 under medical condition of Siddharth Singh (Roll No. 21E80087 – All subjects) and the matter regarding medical leave for one year of Sandeep Chaurasia (Roll No. 20ME8056).**

The matter will be dealt in accordance with the existing norms / provisions of the regulations of UG program.

Item # 11 **To consider the matter on modification of curriculum of M.Sc in Life Sciences and introduction of elective subjects in M.Sc basket as (Annexure III) –**

- **BT9031 – Human Molecular Genetics**
- **BT9033 – Signal Transduction**
- **BT9034 – Molecular Cell Signalling**
- **BT9035 – Food Biotechnology**
- **BT9041 – Advanced rDNA Technology and Cellular Biotechnology**

The matter is recommended for approval.

Item # 12 **To consider the matter on shifting of Open Elective (HSO542: Culture and Communication and MMO541 – Basic Manufacturing Processes) from 5th semester to 7th semester with revised codes HSO742 and MMO741 and introduction of two open elective subjects (CSO744: Computational Biology and its Applications, ECO742: Mobile Communication).**

The matter is recommended for approval (Annexure IV) from the AY 2022-23.

Item # 13 **To consider the matter of DPAC meeting dated 29.04.2022, DAC meeting dated 10.06.2022 and DAC / DPAC meeting dated 28.06.2022 of the Department of Chemical Engineering (Annexure V)–**

- **The change of credit points & syllabus revision for a subject under the PG (Specialization: Chemical Engineering) program.**
- **Offering of Depth Elective (Self-Mastery – CHE 720) for 7th semester UG students.**
- **Proposal for separate Dual Degree program regulations.**

Resolved that

- The change of credit points & syllabus revision for a subject under the PG (Specialization: Chemical Engineering) program. – will be taken up in the next PGAC
- Offering of Depth Elective (Self-Mastery – CHE 720) for 7th semester UG students. – Not recommended as a Depth Elective and referred to the department.
- Proposal for discontinuation of Dual Degree program – will be taken up later.

Item # 14 **To consider the matter of correction of Course code EE 4052 (misprinted as EE 40521 on grade cards) of Course name – "Seminar and Viva Voce" in the grade cards of 4th semester 2009 – 2010 of Electrical Engineering (Electrical Systems) and correction of misprints on the grade cards of all four semesters of M.Sc in**

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Life Sciences and M.Sc in Applied Geology and Geoinformatics for admission year 2020-2021.

The matter is recommended for approval.

Item # 15 **To consider the matter regarding disposal of checked answer scripts of examinations lying with the Departments (UG regulations and PG regulations – clause 12.14).**

Respective departments will take up the matter regarding disposal of checked answer scripts of examinations lying with the Departments with the office of Assistant Registrar (Estate and Security) / Estate Section of the Institute.

Item # 16 **To consider the matter of including electives in the PG curriculum of Microelectronics and VLSI, ECE Department and few open elective subjects for UG curriculum (Annexure IV).**

- **Digital Signal Processing using MATLAB (EC9001) (3-0-2)**
- **Applications of image processing using Python (EC9003) (3-0-2)**
- **FPGA based design (EC9031) (3-0-2)**
- **ASIC design using Verilog / VHDL (EC9036) (3-0-2)**
- **Introduction of following open Elective subjects and some corrections in Minor program (Annexure VI)**

Paper Code	Paper Name
ECO442	Electronic Design
ECO742	Mobile Communication
ECO743	Internet of Things
ECO843	EMI/EMC
ECO853	Electronic System Design

The matter is recommended for approval (ECO742 is already discussed in Item # 12).

Item # 17 **To consider the matter regarding commencement of daily classes from 8.00 am as per routine with class duration of 55 minutes per class.**

The matter is recommended for approval.

The meeting ended with vote of thanks to the Chairman.

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National Institute of Technology
Durgapur-713209 India

Dean (Academic Courses)
Date: 29.07.2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA
18TH CONVOCATION

Annexure - I
UGAC & PGAC (29/07/2022)

TENTATIVE DATE OF CONVOCATION : Second Week of September 2022

LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
1	18BT8001	18U10069	Bachelor of Technology in	Biotechnology	on	Sayanta Ghosh			
2	18BT8002	18U10089	Bachelor of Technology in	Biotechnology	on	Rishavdeb Gayen			
3	18BT8003	18U10116	Bachelor of Technology in	Biotechnology	on	Surjya Roy			
4	18BT8004	18U10119	Bachelor of Technology in	Biotechnology	on	Amlan Mandal			
5	18BT8005	18U10135	Bachelor of Technology in	Biotechnology	on	Sayani Saha			
6	18BT8007	18U10149	Bachelor of Technology in	Biotechnology	on	Arijit Roy			
7	18BT8008	18U10166	Bachelor of Technology in	Biotechnology	on	Bedashruti Majumdar			
8	18BT8009	18U10172	Bachelor of Technology in	Biotechnology	on	Ahana Sarkar			
9	18BT8010	18U10182	Bachelor of Technology in	Biotechnology	on	Subhra Ghosh			
10	18BT8011	18U10192	Bachelor of Technology in	Biotechnology	on	Saikat Paul			
11	18BT8012	18U10214	Bachelor of Technology in	Biotechnology	on	Tushar Shukla			
12	18BT8013	18U10272	Bachelor of Technology in	Biotechnology	on	Priti Maji			
13	18BT8014	18U10298	Bachelor of Technology in	Biotechnology	on	Pragnam Shelsi			
14	18BT8015	18U10314	Bachelor of Technology in	Biotechnology	on	Jintu Moni Nath			
15	18BT8016	18U10381	Bachelor of Technology in	Biotechnology	on	Abhishek Raj			
16	18BT8017	18U10401	Bachelor of Technology in	Biotechnology	on	Panchsheel			
17	18BT8018	18U10455	Bachelor of Technology in	Biotechnology	on	Sabavath Rajesh			
18	18BT8019	18U10457	Bachelor of Technology in	Biotechnology	on	Gondhi Sai Kumar			
19	18BT8021	18U10504	Bachelor of Technology in	Biotechnology	on	Srijini Pal			
20	18BT8024	18U10521	Bachelor of Technology in	Biotechnology	on	Arjya Singh Roy			
21	18BT8025	18U10523	Bachelor of Technology in	Biotechnology	on	Praneet Kumar Sahoo			
22	18BT8026	18U10530	Bachelor of Technology in	Biotechnology	on	Buti Singh			

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA
18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION : Second Week of September 2022
LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
23	18BT8027	18U10536	Bachelor of Technology in	Biotechnology	on	Prarthita Rakshit			
24	18BT8028	18U10537	Bachelor of Technology in	Biotechnology	on	Akash Chowbey			
25	18BT8029	18U10543	Bachelor of Technology in	Biotechnology	on	Saurabh Kumar			
26	18BT8030	18U10544	Bachelor of Technology in	Biotechnology	on	Salari Charan Balajee			
27	18BT8031	18U10549	Bachelor of Technology in	Biotechnology	on	Chavan Swathi			
28	18BT8033	18U10604	Bachelor of Technology in	Biotechnology	on	Anamitra Singha			
29	18BT8034	18U10609	Bachelor of Technology in	Biotechnology	on	Abhrajit Saha			
30	18BT8035	18U10613	Bachelor of Technology in	Biotechnology	on	Sayantan Maity			
31	18BT8036	18U10614	Bachelor of Technology in	Biotechnology	on	Rounak Sarkar			
32	18BT8038	18U10627	Bachelor of Technology in	Biotechnology	on	Garigipati Shivapriya			
33	18BT8040	18U10632	Bachelor of Technology in	Biotechnology	on	Paloju Hari Prasad			
34	18BT8041	18U10639	Bachelor of Technology in	Biotechnology	on	Pratiksha Patel			
35	18BT8042	18U10640	Bachelor of Technology in	Biotechnology	on	Anish Maitra			
36	18BT8043	18U10641	Bachelor of Technology in	Biotechnology	on	Ashish Jaiswal			
37	18BT8044	18U10653	Bachelor of Technology in	Biotechnology	on	Harshit Agrawal			
38	18BT8046	18U10663	Bachelor of Technology in	Biotechnology	on	Sneha Roy			
39	18BT8047	18U10665	Bachelor of Technology in	Biotechnology	on	Mahesh Kumar			
40	18BT8049	18U10672	Bachelor of Technology in	Biotechnology	on	Sujata Mandal			
41	18BT8050	18U10682	Bachelor of Technology in	Biotechnology	on	Priyanka Kumari			
42	18BT8051	18U10683	Bachelor of Technology in	Biotechnology	on	Valasala Lakshmanrao			
43	18BT8052	18U10687	Bachelor of Technology in	Biotechnology	on	Akula Maruthi Ayyannarao			
44	18BT8053	18U10688	Bachelor of Technology in	Biotechnology	on	Dheerendra Goyal			

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
45	18BT8054	18U10693	Bachelor of Technology in	Biotechnology	on	Pratyush Ghosh			
46	18BT8055	18U10695	Bachelor of Technology in	Biotechnology	on	Monu Kumar			
47	18BT8056	18U10698	Bachelor of Technology in	Biotechnology	on	Hari Om			
48	18BT8057	18U10706	Bachelor of Technology in	Biotechnology	on	Bandeppa			
49	18BT8058	18U10710	Bachelor of Technology in	Biotechnology	on	Prakriti Singh			
50	18BT8059	18U10732	Bachelor of Technology in	Biotechnology	on	Parmatma Kumar			
51	18BT8060	18U10744	Bachelor of Technology in	Biotechnology	on	Dwarapudi Rajasekhar			
52	18BT8061	18U10746	Bachelor of Technology in	Biotechnology	on	Kritika Sahoo			
53	18BT8062	18U10756	Bachelor of Technology in	Biotechnology	on	C.V.Manvi			
54	18BT8063	18U10760	Bachelor of Technology in	Biotechnology	on	Yogesh Kumar Dogra			
55	18BT8064	18U10762	Bachelor of Technology in	Biotechnology	on	B Aditi			
56	18BT8065	18U10768	Bachelor of Technology in	Biotechnology	on	Manish Moond			
57	17CE8008	17U10130	Bachelor of Technology in	Civil Engineering	on	Kadai Krishna Majhi			
58	17CE8026	17U10373	Bachelor of Technology in	Civil Engineering	on	Adarsh Kumar Harit			
59	18CE8001	18U10013	Bachelor of Technology in	Civil Engineering	on	Apurba Sardar			
60	18CE8002	18U10058	Bachelor of Technology in	Civil Engineering	on	Tanmoy Sahoo			
61	18CE8003	18U10059	Bachelor of Technology in	Civil Engineering	on	Dipan Kumar Das			
62	18CE8004	18U10066	Bachelor of Technology in	Civil Engineering	on	Sougata Mandi			
63	18CE8005	18U10073	Bachelor of Technology in	Civil Engineering	on	Thyelshangran Moriah Khaling			
64	18CE8006	18U10102	Bachelor of Technology in	Civil Engineering	on	Suman Kumari			
65	18CE8007	18U10104	Bachelor of Technology in	Civil Engineering	on	Bikram Dey			
66	18CE8008	18U10110	Bachelor of Technology in	Civil Engineering	on	Krishanu Sikdar			

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18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION : Second Week of September 2022
LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
67	18CE8009	18U10124	Bachelor of Technology in	Civil Engineering	on	Disha De			
68	18CE8010	18U10129	Bachelor of Technology in	Civil Engineering	on	Debpratim Sinha			
69	18CE8011	18U10150	Bachelor of Technology in	Civil Engineering	on	Md Danish Khan			
70	18CE8012	18U10178	Bachelor of Technology in	Civil Engineering	on	Saurav Kumar			
71	18CE8013	18U10185	Bachelor of Technology in	Civil Engineering	on	Amlan Kar			
72	18CE8014	18U10191	Bachelor of Technology in	Civil Engineering	on	Raghav Acharya			
73	18CE8016	18U10195	Bachelor of Technology in	Civil Engineering	on	Manoj Layek			
74	18CE8017	18U10202	Bachelor of Technology in	Civil Engineering	on	Sourjyendra Krishna Deb			
75	18CE8018	18U10208	Bachelor of Technology in	Civil Engineering	on	Aatif Hanif			
76	18CE8020	18U10291	Bachelor of Technology in	Civil Engineering	on	Kolipakula Uday Kiran			
77	18CE8021	18U10295	Bachelor of Technology in	Civil Engineering	on	Bindas R Jorwal			
78	18CE8022	18U10297	Bachelor of Technology in	Civil Engineering	on	Monavarthi Sri Sai Aadarsh			
79	18CE8023	18U10302	Bachelor of Technology in	Civil Engineering	on	Bolla Sai Gopal			
80	18CE8024	18U10316	Bachelor of Technology in	Civil Engineering	on	Sonu Kumar			
81	18CE8025	18U10320	Bachelor of Technology in	Civil Engineering	on	Suman Kumar Patra			
82	18CE8026	18U10322	Bachelor of Technology in	Civil Engineering	on	Shraddha Majumder			
83	18CE8027	18U10327	Bachelor of Technology in	Civil Engineering	on	Abhinav Verma			
84	18CE8028	18U10333	Bachelor of Technology in	Civil Engineering	on	Kishan Kumar			
85	18CE8029	18U10335	Bachelor of Technology in	Civil Engineering	on	Saurabh Kumar Singh			
86	18CE8030	18U10338	Bachelor of Technology in	Civil Engineering	on	Masarapu Naga Karishma Mounika			
87	18CE8031	18U10391	Bachelor of Technology in	Civil Engineering	on	Kalluri Raja Shekar Reddy			
88	18CE8032	18U10402	Bachelor of Technology in	Civil Engineering	on	Debanjan Mahalanabis			

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
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18TH CONVOCATION
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LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
89	18CE8033	18U10424	Bachelor of Technology in	Civil Engineering	on	Atul Kumar			
90	18CE8034	18U10427	Bachelor of Technology in	Civil Engineering	on	Shalini Satapathy			
91	18CE8035	18U10434	Bachelor of Technology in	Civil Engineering	on	Duppada Sai Kowshik			
92	18CE8036	18U10438	Bachelor of Technology in	Civil Engineering	on	Ashwini Gupta			
93	18CE8037	18U10497	Bachelor of Technology in	Civil Engineering	on	Naragana Jaya Chandra Gowd			
94	18CE8038	18U10512	Bachelor of Technology in	Civil Engineering	on	Sujoy Bhattacharya			
95	18CE8039	18U10519	Bachelor of Technology in	Civil Engineering	on	Saikat Ghosh			
96	18CE8040	18U10527	Bachelor of Technology in	Civil Engineering	on	Anitra Koner			
97	18CE8041	18U10531	Bachelor of Technology in	Civil Engineering	on	Subhajoy Mahanta			
98	18CE8042	18U10538	Bachelor of Technology in	Civil Engineering	on	Lankothu Damaraka Akhil			
99	18CE8044	18U10575	Bachelor of Technology in	Civil Engineering	on	Ankit Chaudhary			
100	18CE8045	18U10576	Bachelor of Technology in	Civil Engineering	on	Nipun Kumar			
101	18CE8046	18U10579	Bachelor of Technology in	Civil Engineering	on	Aurojeet Jena			
102	18CE8047	18U10582	Bachelor of Technology in	Civil Engineering	on	Sumana Nath			
103	18CE8048	18U10592	Bachelor of Technology in	Civil Engineering	on	Avinash Singh			
104	18CE8049	18U10597	Bachelor of Technology in	Civil Engineering	on	Gourab Agarwal			
105	18CE8050	18U10601	Bachelor of Technology in	Civil Engineering	on	Arka Mandal			
106	18CE8051	18U10606	Bachelor of Technology in	Civil Engineering	on	Debojyoti Mandal			
107	18CE8052	18U10618	Bachelor of Technology in	Civil Engineering	on	Sayantan Bishnu			
108	18CE8053	18U10619	Bachelor of Technology in	Civil Engineering	on	Aradhya Rajor			
109	18CE8054	18U10626	Bachelor of Technology in	Civil Engineering	on	Kolla Sudhir Kumar			
110	18CE8055	18U10642	Bachelor of Technology in	Civil Engineering	on	Sudhanshu Saumya			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
111	18CE8056	18U10643	Bachelor of Technology in	Civil Engineering	on	Shalini Roy			
112	18CE8058	18U10661	Bachelor of Technology in	Civil Engineering	on	Dhulipala Dheeraj			
113	18CE8059	18U10708	Bachelor of Technology in	Civil Engineering	on	Ankita Raj			
114	18CE8060	18U10713	Bachelor of Technology in	Civil Engineering	on	Devisetty Sabari Deekshith			
115	18CE8061	18U10718	Bachelor of Technology in	Civil Engineering	on	Pavuluri Ruthwik Venkata Siva Sai			
116	18CE8062	18U10740	Bachelor of Technology in	Civil Engineering	on	Gedala Naidu			
117	18CE8063	18U10761	Bachelor of Technology in	Civil Engineering	on	Jijith Sudev			
118	18CE8064	18U10765	Bachelor of Technology in	Civil Engineering	on	S Meynesh			
119	18CH8001	18U10022	Bachelor of Technology in	Chemical Engineering	on	Souvik Ghosh			
120	18CH8003	18U10046	Bachelor of Technology in	Chemical Engineering	on	Tiyasha Ghosh			
121	18CH8004	18U10062	Bachelor of Technology in	Chemical Engineering	on	Soham Roy Chowdhury			
122	18CH8005	18U10063	Bachelor of Technology in	Chemical Engineering	on	Rhythm Aich			
123	18CH8006	18U10083	Bachelor of Technology in	Chemical Engineering	on	Arnab Mandal			
124	18CH8007	18U10099	Bachelor of Technology in	Chemical Engineering	on	Souma Das			
125	18CH8008	18U10100	Bachelor of Technology in	Chemical Engineering	on	Rishav Kumar Rathore			
126	18CH8009	18U10113	Bachelor of Technology in	Chemical Engineering	on	Kusuma Vasanth Kumar			
127	18CH8010	18U10134	Bachelor of Technology in	Chemical Engineering	on	Pritam Mandal			
128	18CH8011	18U10139	Bachelor of Technology in	Chemical Engineering	on	Joy Mallick			
129	18CH8012	18U10146	Bachelor of Technology in	Chemical Engineering	on	Kritika Raman			
130	18CH8013	18U10151	Bachelor of Technology in	Chemical Engineering	on	Annasha Dey			
131	18CH8014	18U10197	Bachelor of Technology in	Chemical Engineering	on	Samannoy Mukherjee			
132	18CH8015	18U10223	Bachelor of Technology in	Chemical Engineering	on	Ankita Bhattacharya			

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133	18CH8017	18U10242	Bachelor of Technology in	Chemical Engineering	on	Satendra Singh			
134	18CH8018	18U10261	Bachelor of Technology in	Chemical Engineering	on	Harshit Shrinet			
135	18CH8019	18U10270	Bachelor of Technology in	Chemical Engineering	on	Saumyajeet Mukherjee			
136	18CH8020	18U10274	Bachelor of Technology in	Chemical Engineering	on	Priyabrata Pani			
137	18CH8021	18U10280	Bachelor of Technology in	Chemical Engineering	on	Sk Asfak Uddin			
138	18CH8022	18U10283	Bachelor of Technology in	Chemical Engineering	on	Aranyo Banerjee			
139	18CH8023	18U10289	Bachelor of Technology in	Chemical Engineering	on	Kareena Deka Baruah			
140	18CH8024	18U10294	Bachelor of Technology in	Chemical Engineering	on	Ashis Bera			
141	18CH8025	18U10300	Bachelor of Technology in	Chemical Engineering	on	Somayajula Rittika			
142	18CH8026	18U10307	Bachelor of Technology in	Chemical Engineering	on	Abhishek Dey			
143	18CH8027	18U10317	Bachelor of Technology in	Chemical Engineering	on	Ayush Nath			
144	18CH8028	18U10323	Bachelor of Technology in	Chemical Engineering	on	Arnav Hemant Sakhare			
145	18CH8029	18U10361	Bachelor of Technology in	Chemical Engineering	on	Vivek Garg			
146	18CH8030	18U10364	Bachelor of Technology in	Chemical Engineering	on	Chitikala Gireswar			
147	18CH8031	18U10376	Bachelor of Technology in	Chemical Engineering	on	Ashutosh Mishra			
148	18CH8032	18U10400	Bachelor of Technology in	Chemical Engineering	on	Moirangthem Sarda Devi			
149	18CH8033	18U10404	Bachelor of Technology in	Chemical Engineering	on	Addepalli Sai Sanjay Varma			
150	18CH8035	18U10409	Bachelor of Technology in	Chemical Engineering	on	Piyanjana Ghosh			
151	18CH8036	18U10441	Bachelor of Technology in	Chemical Engineering	on	Md Yasin Ansari			
152	18CH8037	18U10446	Bachelor of Technology in	Chemical Engineering	on	Puli Prasanna Paul			
153	18CH8038	18U10447	Bachelor of Technology in	Chemical Engineering	on	Saikat Das			
154	18CH8039	18U10466	Bachelor of Technology in	Chemical Engineering	on	Muta Giridhar Naidu			

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155	18CH8041	18U10505	Bachelor of Technology in	Chemical Engineering	on	Suchismita Khan			
156	18CH8042	18U10509	Bachelor of Technology in	Chemical Engineering	on	Gourab Mondal			
157	18CH8043	18U10517	Bachelor of Technology in	Chemical Engineering	on	Laxmi Saro Hembrom			
158	18CH8044	18U10541	Bachelor of Technology in	Chemical Engineering	on	Souvik Daripa			
159	18CH8045	18U10554	Bachelor of Technology in	Chemical Engineering	on	Samriddha Saha			
160	18CH8046	18U10558	Bachelor of Technology in	Chemical Engineering	on	Vivek Sunil Kumar Jha			
161	18CH8047	18U10559	Bachelor of Technology in	Chemical Engineering	on	Varun Kumar Singh			
162	18CH8048	18U10562	Bachelor of Technology in	Chemical Engineering	on	P M R Vedhanand			
163	18CH8049	18U10571	Bachelor of Technology in	Chemical Engineering	on	Tamoghna Bhattacharjee			
164	18CH8051	18U10589	Bachelor of Technology in	Chemical Engineering	on	Amar Kumar Pandey			
165	18CH8052	18U10616	Bachelor of Technology in	Chemical Engineering	on	Sakshi Singh			
166	18CH8053	18U10635	Bachelor of Technology in	Chemical Engineering	on	Piyush Kumar Dwivedi			
167	18CH8054	18U10637	Bachelor of Technology in	Chemical Engineering	on	Sneha Rani Dey			
168	18CH8055	18U10664	Bachelor of Technology in	Chemical Engineering	on	Anuj Patel			
169	18CH8056	18U10674	Bachelor of Technology in	Chemical Engineering	on	Proshanta Singha			
170	18CH8057	18U10681	Bachelor of Technology in	Chemical Engineering	on	Kiranmaya Puhan			
171	18CH8058	18U10686	Bachelor of Technology in	Chemical Engineering	on	Mohd Sakir			
172	18CH8060	18U10723	Bachelor of Technology in	Chemical Engineering	on	Abhinandan Kumar			
173	18CH8061	18U10733	Bachelor of Technology in	Chemical Engineering	on	Deerasa			
174	18CH8062	18U10734	Bachelor of Technology in	Chemical Engineering	on	Zeeshan Akhtar			
175	18CH8063	18U10735	Bachelor of Technology in	Chemical Engineering	on	Badavath Suman			
176	17CS8003	17U10004	Bachelor of Technology in	Computer Science and Engineering	on	Swarnavo Chakrabarti			

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177	18CS8001	18U10001	Bachelor of Technology in	Computer Science and Engineering	on	Spandan Pal			
178	18CS8002	18U10002	Bachelor of Technology in	Computer Science and Engineering	on	Binit Kumar Singh			
179	18CS8003	18U10004	Bachelor of Technology in	Computer Science and Engineering	on	Sayan Pal			
180	18CS8004	18U10006	Bachelor of Technology in	Computer Science and Engineering	on	Reeya Raj Singh			
181	18CS8005	18U10007	Bachelor of Technology in	Computer Science and Engineering	on	Shriya Das			
182	18CS8007	18U10016	Bachelor of Technology in	Computer Science and Engineering	on	Amish Bharti			
183	18CS8008	18U10018	Bachelor of Technology in	Computer Science and Engineering	on	Saurav Das			
184	18CS8009	18U10019	Bachelor of Technology in	Computer Science and Engineering	on	Shubhank Chandak			
185	18CS8010	18U10020	Bachelor of Technology in	Computer Science and Engineering	on	Debaditya Dutta			
186	18CS8011	18U10021	Bachelor of Technology in	Computer Science and Engineering	on	Shaon Kumar Debnath			
187	18CS8012	18U10033	Bachelor of Technology in	Computer Science and Engineering	on	Shreoshree Adhikari			
188	18CS8013	18U10038	Bachelor of Technology in	Computer Science and Engineering	on	Avinandan Pal			
189	18CS8014	18U10040	Bachelor of Technology in	Computer Science and Engineering	on	Rohit Lama			
190	18CS8015	18U10042	Bachelor of Technology in	Computer Science and Engineering	on	Subhayu Ghosh			
191	18CS8016	18U10048	Bachelor of Technology in	Computer Science and Engineering	on	Saswata Bagchi			
192	18CS8017	18U10051	Bachelor of Technology in	Computer Science and Engineering	on	Sumana Mukherjee			
193	18CS8018	18U10052	Bachelor of Technology in	Computer Science and Engineering	on	Hritesh Mourya			
194	18CS8019	18U10053	Bachelor of Technology in	Computer Science and Engineering	on	Romit Karmakar			
195	18CS8020	18U10054	Bachelor of Technology in	Computer Science and Engineering	on	Abhik Mahato			
196	18CS8021	18U10055	Bachelor of Technology in	Computer Science and Engineering	on	Riddhi Roy			
197	18CS8022	18U10056	Bachelor of Technology in	Computer Science and Engineering	on	Sarfaraz Ahmad			
198	18CS8023	18U10061	Bachelor of Technology in	Computer Science and Engineering	on	Manish Manojan			

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199	18CS8024	18U10067	Bachelor of Technology in	Computer Science and Engineering	on	Molla Saroyar Hossain			
200	18CS8025	18U10071	Bachelor of Technology in	Computer Science and Engineering	on	Anirban Nayek			
201	18CS8026	18U10072	Bachelor of Technology in	Computer Science and Engineering	on	Devam Kumar Anand			
202	18CS8027	18U10077	Bachelor of Technology in	Computer Science and Engineering	on	Surya Prakash			
203	18CS8028	18U10079	Bachelor of Technology in	Computer Science and Engineering	on	Prasun Kumar Bhuin			
204	18CS8029	18U10080	Bachelor of Technology in	Computer Science and Engineering	on	Aman Lama			
205	18CS8030	18U10082	Bachelor of Technology in	Computer Science and Engineering	on	Pritam Dutta			
206	18CS8031	18U10085	Bachelor of Technology in	Computer Science and Engineering	on	Karan Singh			
207	18CS8032	18U10086	Bachelor of Technology in	Computer Science and Engineering	on	Rohit Shukla			
208	18CS8033	18U10087	Bachelor of Technology in	Computer Science and Engineering	on	Himanshu Shekhar Jha			
209	18CS8035	18U10105	Bachelor of Technology in	Computer Science and Engineering	on	Rajnish Raj			
210	18CS8036	18U10115	Bachelor of Technology in	Computer Science and Engineering	on	Abhishek Kumar			
211	18CS8037	18U10117	Bachelor of Technology in	Computer Science and Engineering	on	Choppala Paul Bright			
212	18CS8039	18U10127	Bachelor of Technology in	Computer Science and Engineering	on	Sourav Karmakar			
213	18CS8041	18U10144	Bachelor of Technology in	Computer Science and Engineering	on	Pratim Mandal			
214	18CS8042	18U10148	Bachelor of Technology in	Computer Science and Engineering	on	Aniket Ray			
215	18CS8044	18U10153	Bachelor of Technology in	Computer Science and Engineering	on	Proma Roy			
216	18CS8045	18U10157	Bachelor of Technology in	Computer Science and Engineering	on	Sailesh Kumar			
217	18CS8046	18U10159	Bachelor of Technology in	Computer Science and Engineering	on	Swarup Roy			
218	18CS8047	18U10161	Bachelor of Technology in	Computer Science and Engineering	on	Akarshan Chatterjee			
219	18CS8048	18U10162	Bachelor of Technology in	Computer Science and Engineering	on	Vaibhav Misra			
220	18CS8049	18U10164	Bachelor of Technology in	Computer Science and Engineering	on	Alka Oraon			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
221	18CS8050	18U10167	Bachelor of Technology in	Computer Science and Engineering	on	Avirup Mazumder			
222	18CS8051	18U10170	Bachelor of Technology in	Computer Science and Engineering	on	Anupam Minj			
223	18CS8052	18U10174	Bachelor of Technology in	Computer Science and Engineering	on	Onkar Sardar			
224	18CS8053	18U10179	Bachelor of Technology in	Computer Science and Engineering	on	Nitesh Kumar Prasad			
225	18CS8054	18U10187	Bachelor of Technology in	Computer Science and Engineering	on	Kotana Sai			
226	18CS8055	18U10190	Bachelor of Technology in	Computer Science and Engineering	on	Joyeeta Mandal			
227	18CS8056	18U10196	Bachelor of Technology in	Computer Science and Engineering	on	Nisha Bharti			
228	18CS8057	18U10201	Bachelor of Technology in	Computer Science and Engineering	on	Jugnu			
229	18CS8058	18U10207	Bachelor of Technology in	Computer Science and Engineering	on	Madiki Mounika			
230	18CS8059	18U10211	Bachelor of Technology in	Computer Science and Engineering	on	Thota Sugandha Siddieswar			
231	18CS8060	18U10219	Bachelor of Technology in	Computer Science and Engineering	on	Rajendra Nath Murmu			
232	18CS8061	18U10222	Bachelor of Technology in	Computer Science and Engineering	on	Saharsh Ananta Jaiswal			
233	18CS8062	18U10226	Bachelor of Technology in	Computer Science and Engineering	on	Pudi Pavan Kumar			
234	18CS8063	18U10233	Bachelor of Technology in	Computer Science and Engineering	on	Ayesha Uzma			
235	18CS8064	18U10238	Bachelor of Technology in	Computer Science and Engineering	on	Rithik Sureka			
236	18CS8065	18U10243	Bachelor of Technology in	Computer Science and Engineering	on	Ravupalli Harsha Vardhan			
237	18CS8066	18U10247	Bachelor of Technology in	Computer Science and Engineering	on	Indrajeet Soreng			
238	18CS8067	18U10248	Bachelor of Technology in	Computer Science and Engineering	on	Nitesh Kumar			
239	18CS8068	18U10250	Bachelor of Technology in	Computer Science and Engineering	on	Chilukuri Sri Harsha			
240	18CS8069	18U10252	Bachelor of Technology in	Computer Science and Engineering	on	Md Afzal Nayeem			
241	18CS8070	18U10253	Bachelor of Technology in	Computer Science and Engineering	on	Md Umar			
242	18CS8071	18U10254	Bachelor of Technology in	Computer Science and Engineering	on	Simran Singh			

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243	18CS8072	18U10255	Bachelor of Technology in	Computer Science and Engineering	on	Ashwini Suryawanshi			
244	18CS8073	18U10262	Bachelor of Technology in	Computer Science and Engineering	on	Samrat Kundu			
245	18CS8074	18U10264	Bachelor of Technology in	Computer Science and Engineering	on	Penumuchu Sri Satwik			
246	18CS8075	18U10277	Bachelor of Technology in	Computer Science and Engineering	on	Varsha Tanti			
247	18CS8076	18U10279	Bachelor of Technology in	Computer Science and Engineering	on	Saptarshi Mondal			
248	18CS8077	18U10281	Bachelor of Technology in	Computer Science and Engineering	on	Priyesh Deep Kumar			
249	18CS8078	18U10286	Bachelor of Technology in	Computer Science and Engineering	on	Kala Yaduveera Chowdaiah			
250	18CS8079	18U10287	Bachelor of Technology in	Computer Science and Engineering	on	Kalivarapu Adithya			
251	18CS8080	18U10288	Bachelor of Technology in	Computer Science and Engineering	on	Debananda Das			
252	18CS8081	18U10305	Bachelor of Technology in	Computer Science and Engineering	on	Dolly Raj			
253	18CS8082	18U10318	Bachelor of Technology in	Computer Science and Engineering	on	Mohammed Yaseen			
254	18CS8084	18U10328	Bachelor of Technology in	Computer Science and Engineering	on	Raju Hoque			
255	18CS8085	18U10336	Bachelor of Technology in	Computer Science and Engineering	on	Martand Pratap Singh			
256	18CS8086	18U10340	Bachelor of Technology in	Computer Science and Engineering	on	Nokom Konyak			
257	18CS8087	18U10344	Bachelor of Technology in	Computer Science and Engineering	on	Vishwas Verma			
258	18CS8088	18U10345	Bachelor of Technology in	Computer Science and Engineering	on	Vasireddy Veeraveni Mahalakshmi			
259	18CS8089	18U10350	Bachelor of Technology in	Computer Science and Engineering	on	Risabh Udgata			
260	18CS8090	18U10352	Bachelor of Technology in	Computer Science and Engineering	on	Vemu Reesa Rejoice			
261	18CS8092	18U10359	Bachelor of Technology in	Computer Science and Engineering	on	Banoth Naresh			
262	18CS8093	18U10363	Bachelor of Technology in	Computer Science and Engineering	on	Konuganti Naveen Reddy			
263	18CS8094	18U10366	Bachelor of Technology in	Computer Science and Engineering	on	Seelam Penchala Prathush Goud			
264	18CS8096	18U10372	Bachelor of Technology in	Computer Science and Engineering	on	Prince			

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265	18CS8097	18U10373	Bachelor of Technology in	Computer Science and Engineering	on	Arya Verma			
266	18CS8098	18U10378	Bachelor of Technology in	Computer Science and Engineering	on	Prakhar Kumar			
267	18CS8099	18U10379	Bachelor of Technology in	Computer Science and Engineering	on	Suneha Maiti			
268	18CS8101	18U10383	Bachelor of Technology in	Computer Science and Engineering	on	Sampark Sharma			
269	18CS8102	18U10385	Bachelor of Technology in	Computer Science and Engineering	on	Duvvuri Veereshwara Satya Vineeth			
270	18CS8103	18U10386	Bachelor of Technology in	Computer Science and Engineering	on	Patel Rushil			
271	18CS8104	18U10388	Bachelor of Technology in	Computer Science and Engineering	on	Surapureddi Venkata Sai Harshith			
272	18CS8105	18U10389	Bachelor of Technology in	Computer Science and Engineering	on	Shankhasubhro Roy			
273	18CS8106	18U10390	Bachelor of Technology in	Computer Science and Engineering	on	Buchala Dheeraj Kumar			
274	18CS8107	18U10396	Bachelor of Technology in	Computer Science and Engineering	on	Alla Dharma Teja			
275	18CS8108	18U10397	Bachelor of Technology in	Computer Science and Engineering	on	Priyanshu Verma			
276	18CS8109	18U10399	Bachelor of Technology in	Computer Science and Engineering	on	Vydana Sai Aakash			
277	18CS8110	18U10416	Bachelor of Technology in	Computer Science and Engineering	on	Gangala Charmila Tanvi			
278	18CS8111	18U10429	Bachelor of Technology in	Computer Science and Engineering	on	Kalvakuntla Phani Santhosh			
279	18CS8112	18U10433	Bachelor of Technology in	Computer Science and Engineering	on	Madhila Devaraju			
280	18CS8113	18U10436	Bachelor of Technology in	Computer Science and Engineering	on	Machammagari Parthasai Reddy			
281	18CS8114	18U10442	Bachelor of Technology in	Computer Science and Engineering	on	Devam Kakoty			
282	18CS8115	18U10443	Bachelor of Technology in	Computer Science and Engineering	on	Devraj Kakoty			
283	18CS8116	18U10445	Bachelor of Technology in	Computer Science and Engineering	on	Shrimoyee Ghosh			
284	18CS8117	18U10448	Bachelor of Technology in	Computer Science and Engineering	on	Mohit Agarwal			
285	18CS8118	18U10452	Bachelor of Technology in	Computer Science and Engineering	on	Aryan Kodap			
286	18CS8119	18U10453	Bachelor of Technology in	Computer Science and Engineering	on	Mohammed Shahin Sharafudheen			

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287	18CS8120	18U10458	Bachelor of Technology in	Computer Science and Engineering	on	Hindol Kumar Das			
288	18CS8121	18U10459	Bachelor of Technology in	Computer Science and Engineering	on	Arjun Menon			
289	18CS8122	18U10463	Bachelor of Technology in	Computer Science and Engineering	on	Badnaini Lavanya			
290	18CS8123	18U10472	Bachelor of Technology in	Computer Science and Engineering	on	Kajal Meghani			
291	18CS8124	18U10473	Bachelor of Technology in	Computer Science and Engineering	on	Amit Bose			
292	18CS8125	18U10475	Bachelor of Technology in	Computer Science and Engineering	on	Srijeeta Das			
293	18CS8126	18U10476	Bachelor of Technology in	Computer Science and Engineering	on	Diganta Mitra			
294	18CS8127	18U10482	Bachelor of Technology in	Computer Science and Engineering	on	Soumik Samanta			
295	18CS8128	18U10483	Bachelor of Technology in	Computer Science and Engineering	on	Ayan Sarkar			
296	18CS8129	18U10484	Bachelor of Technology in	Computer Science and Engineering	on	Akash Manna			
297	18CS8130	18U10487	Bachelor of Technology in	Computer Science and Engineering	on	Aritro Saha			
298	18CS8131	18U10488	Bachelor of Technology in	Computer Science and Engineering	on	Shubham Kumar			
299	18CS8132	18U10489	Bachelor of Technology in	Computer Science and Engineering	on	Vikash Churiwala			
300	18CS8133	18U10491	Bachelor of Technology in	Computer Science and Engineering	on	Ganugula Suneetha			
301	18CS8134	18U10494	Bachelor of Technology in	Computer Science and Engineering	on	Yathansh A Jain			
302	18CS8135	18U10496	Bachelor of Technology in	Computer Science and Engineering	on	Subhodeep Santra			
303	18CS8136	18U10498	Bachelor of Technology in	Computer Science and Engineering	on	Chirag Agarwal			
304	18CS8137	18U10503	Bachelor of Technology in	Computer Science and Engineering	on	Ankit Jaiswal			
305	18CS8138	18U10514	Bachelor of Technology in	Computer Science and Engineering	on	Abhishek Gupta			
306	18CS8139	18U10515	Bachelor of Technology in	Computer Science and Engineering	on	Arunava Sarkar			
307	18CS8140	18U10522	Bachelor of Technology in	Computer Science and Engineering	on	Rajas Ajay Kulkarni			
308	18CS8141	18U10528	Bachelor of Technology in	Computer Science and Engineering	on	Soumyodeep Dey			

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309	18CS8142	18U10547	Bachelor of Technology in	Computer Science and Engineering	on	Jonnala Keerthi			
310	18CS8143	18U10548	Bachelor of Technology in	Computer Science and Engineering	on	Pedakota Venkatasai Priyatham			
311	18CS8144	18U10553	Bachelor of Technology in	Computer Science and Engineering	on	Avinesh			
312	18CS8145	18U10569	Bachelor of Technology in	Computer Science and Engineering	on	Paritosh Mahapatra			
313	18CS8146	18U10572	Bachelor of Technology in	Computer Science and Engineering	on	Ayush Gupta			
314	18CS8147	18U10585	Bachelor of Technology in	Computer Science and Engineering	on	Mogali Raghu Ram			
315	18CS8148	18U10596	Bachelor of Technology in	Computer Science and Engineering	on	Sripada Yaswanth Kalyan			
316	18CS8149	18U10610	Bachelor of Technology in	Computer Science and Engineering	on	Vaddavalli Sai Sita Ram			
317	18CS8150	18U10622	Bachelor of Technology in	Computer Science and Engineering	on	Abhishek Rangana			
318	18CS8151	18U10630	Bachelor of Technology in	Computer Science and Engineering	on	Utkarsh Agarwal			
319	18CS8152	18U10645	Bachelor of Technology in	Computer Science and Engineering	on	Deepak Kumar			
320	18CS8153	18U10646	Bachelor of Technology in	Computer Science and Engineering	on	Dalu Ajay Prashanth			
321	18CS8154	18U10649	Bachelor of Technology in	Computer Science and Engineering	on	Rana Dilendra Singh			
322	18CS8155	18U10657	Bachelor of Technology in	Computer Science and Engineering	on	Shubhankar Chakrabarty			
323	18CS8156	18U10660	Bachelor of Technology in	Computer Science and Engineering	on	Khan Azhar			
324	18CS8157	18U10666	Bachelor of Technology in	Computer Science and Engineering	on	Rahul Lodha			
325	18CS8158	18U10709	Bachelor of Technology in	Computer Science and Engineering	on	Gottapu Geeta Deepika			
326	18CS8159	18U10727	Bachelor of Technology in	Computer Science and Engineering	on	Erikipati Karthik			
327	18CS8160	18U10737	Bachelor of Technology in	Computer Science and Engineering	on	Dhiraj Chaurasia			
328	18CS8161	18U10742	Bachelor of Technology in	Computer Science and Engineering	on	Simhavishnu Ram Prasad			
329	18CS8162	18U10743	Bachelor of Technology in	Computer Science and Engineering	on	Binita Karmakar			
330	18CS8163	18U10748	Bachelor of Technology in	Computer Science and Engineering	on	Snehit Mishra			

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331	18CS8164	18U10751	Bachelor of Technology in	Computer Science and Engineering	on	Depankar Bisoy			
332	18CS8165	18U10759	Bachelor of Technology in	Computer Science and Engineering	on	Anto Prathik Savio Pravin			
333	18CS8166	18U10764	Bachelor of Technology in	Computer Science and Engineering	on	Vimal Kumar Dubey			
334	18EC8001	18U10015	Bachelor of Technology in	Electronics and Communication Engineering	on	Adarsh Verma			
335	18EC8002	18U10023	Bachelor of Technology in	Electronics and Communication Engineering	on	Vikash Kumar Yadav			
336	18EC8003	18U10025	Bachelor of Technology in	Electronics and Communication Engineering	on	Mithilesh Halder			
337	18EC8004	18U10028	Bachelor of Technology in	Electronics and Communication Engineering	on	Jyotishka Dasgupta			
338	18EC8005	18U10029	Bachelor of Technology in	Electronics and Communication Engineering	on	Koushik Karmakar			
339	18EC8006	18U10032	Bachelor of Technology in	Electronics and Communication Engineering	on	Sujana Pal			
340	18EC8007	18U10034	Bachelor of Technology in	Electronics and Communication Engineering	on	Surajit Mondal			
341	18EC8008	18U10039	Bachelor of Technology in	Electronics and Communication Engineering	on	Koushik Kumar Das			
342	18EC8009	18U10043	Bachelor of Technology in	Electronics and Communication Engineering	on	Priya			
343	18EC8010	18U10060	Bachelor of Technology in	Electronics and Communication Engineering	on	Avinash Kumar			
344	18EC8011	18U10070	Bachelor of Technology in	Electronics and Communication Engineering	on	Hrithik Panda			
345	18EC8012	18U10084	Bachelor of Technology in	Electronics and Communication Engineering	on	Dipak Biswakarma			
346	18EC8013	18U10091	Bachelor of Technology in	Electronics and Communication Engineering	on	Brinta Das			
347	18EC8014	18U10101	Bachelor of Technology in	Electronics and Communication Engineering	on	Abhishek Narayan Sarkar			
348	18EC8015	18U10112	Bachelor of Technology in	Electronics and Communication Engineering	on	Geetha Charan Duba			
349	18EC8016	18U10133	Bachelor of Technology in	Electronics and Communication Engineering	on	Aratla Pavani			
350	18EC8018	18U10154	Bachelor of Technology in	Electronics and Communication Engineering	on	Ayushman Banerjee			
351	18EC8020	18U10188	Bachelor of Technology in	Electronics and Communication Engineering	on	Anusha Ghosh			
352	18EC8021	18U10198	Bachelor of Technology in	Electronics and Communication Engineering	on	Pritam Kumar Biswas			

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353	18EC8022	18U10228	Bachelor of Technology in	Electronics and Communication Engineering	on	Hridoy Sutar			
354	18EC8023	18U10231	Bachelor of Technology in	Electronics and Communication Engineering	on	Abhishek Kumar Jaiswal			
355	18EC8024	18U10232	Bachelor of Technology in	Electronics and Communication Engineering	on	Sweta Rakhecha			
356	18EC8025	18U10235	Bachelor of Technology in	Electronics and Communication Engineering	on	Burada Teja Ashok			
357	18EC8026	18U10237	Bachelor of Technology in	Electronics and Communication Engineering	on	Syed Ziaul Islam			
358	18EC8027	18U10244	Bachelor of Technology in	Electronics and Communication Engineering	on	Kodali Likhitha			
359	18EC8028	18U10260	Bachelor of Technology in	Electronics and Communication Engineering	on	Promit Roy			
360	18EC8029	18U10284	Bachelor of Technology in	Electronics and Communication Engineering	on	Daggupati Bala Sai Pavan Kumar			
361	18EC8030	18U10292	Bachelor of Technology in	Electronics and Communication Engineering	on	Sourav Kumar Shaw			
362	18EC8031	18U10301	Bachelor of Technology in	Electronics and Communication Engineering	on	Nitisha Singh			
363	18EC8032	18U10303	Bachelor of Technology in	Electronics and Communication Engineering	on	Pritish Singhal			
364	18EC8033	18U10306	Bachelor of Technology in	Electronics and Communication Engineering	on	Soumya Chatterjee			
365	18EC8034	18U10308	Bachelor of Technology in	Electronics and Communication Engineering	on	Vivek Sharma			
366	18EC8035	18U10310	Bachelor of Technology in	Electronics and Communication Engineering	on	Kolluru Sai Charan			
367	18EC8036	18U10325	Bachelor of Technology in	Electronics and Communication Engineering	on	Vithanala Yamini			
368	18EC8037	18U10329	Bachelor of Technology in	Electronics and Communication Engineering	on	Mohammad Ashir			
369	18EC8038	18U10330	Bachelor of Technology in	Electronics and Communication Engineering	on	Dunna Rajeev Prakash			
370	18EC8039	18U10334	Bachelor of Technology in	Electronics and Communication Engineering	on	Bandi Mani Shankar			
371	18EC8040	18U10339	Bachelor of Technology in	Electronics and Communication Engineering	on	Gummidi Vamsi Sai Madhu			
372	18EC8041	18U10343	Bachelor of Technology in	Electronics and Communication Engineering	on	Ankit Chauhan			
373	18EC8042	18U10353	Bachelor of Technology in	Electronics and Communication Engineering	on	Mandru Sanjay Kumar			
374	18EC8043	18U10362	Bachelor of Technology in	Electronics and Communication Engineering	on	Vinay Kushapuram			

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375	18EC8044	18U10365	Bachelor of Technology in	Electronics and Communication Engineering	on	Donthireddy Dinesh Reddy			
376	18EC8045	18U10371	Bachelor of Technology in	Electronics and Communication Engineering	on	Yash Vishnoi			
377	18EC8046	18U10377	Bachelor of Technology in	Electronics and Communication Engineering	on	Shashank Singh			
378	18EC8047	18U10387	Bachelor of Technology in	Electronics and Communication Engineering	on	Sanjoy Mallick			
379	18EC8048	18U10395	Bachelor of Technology in	Electronics and Communication Engineering	on	Samujjal Suni Mochahari			
380	18EC8049	18U10406	Bachelor of Technology in	Electronics and Communication Engineering	on	Pawan Kumar			
381	18EC8050	18U10410	Bachelor of Technology in	Electronics and Communication Engineering	on	Sanumala Moses			
382	18EC8051	18U10414	Bachelor of Technology in	Electronics and Communication Engineering	on	Uppada Bhanu Reddy			
383	18EC8052	18U10419	Bachelor of Technology in	Electronics and Communication Engineering	on	Singineedi Sainath			
384	18EC8053	18U10421	Bachelor of Technology in	Electronics and Communication Engineering	on	Ayush Abhishek Kujur			
385	18EC8054	18U10422	Bachelor of Technology in	Electronics and Communication Engineering	on	Kusumanchi V Satya Surya Kalki Rakesh			
386	18EC8055	18U10423	Bachelor of Technology in	Electronics and Communication Engineering	on	Kondapi V S Krishna Praveen			
387	18EC8056	18U10425	Bachelor of Technology in	Electronics and Communication Engineering	on	Perimi Vishnu Vardhan			
388	18EC8057	18U10439	Bachelor of Technology in	Electronics and Communication Engineering	on	Nareddy Abhinay Kumar Reddy			
389	18EC8058	18U10454	Bachelor of Technology in	Electronics and Communication Engineering	on	Madhumita Mandal			
390	18EC8059	18U10456	Bachelor of Technology in	Electronics and Communication Engineering	on	Neharika Shah			
391	18EC8060	18U10471	Bachelor of Technology in	Electronics and Communication Engineering	on	Munshi Ajfar Rahaman			
392	18EC8061	18U10478	Bachelor of Technology in	Electronics and Communication Engineering	on	Inaganti Kashyap			
393	18EC8062	18U10480	Bachelor of Technology in	Electronics and Communication Engineering	on	Mukesh Kumar Gupta			
394	18EC8063	18U10485	Bachelor of Technology in	Electronics and Communication Engineering	on	Animesh Datta			
395	18EC8064	18U10486	Bachelor of Technology in	Electronics and Communication Engineering	on	Chowdhury Arunima Nishi			
396	18EC8065	18U10493	Bachelor of Technology in	Electronics and Communication Engineering	on	Satti Jyothi			

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397	18EC8067	18U10529	Bachelor of Technology in	Electronics and Communication Engineering	on	Rounak Das			
398	18EC8068	18U10555	Bachelor of Technology in	Electronics and Communication Engineering	on	Shankar Das Banerjee			
399	18EC8069	18U10581	Bachelor of Technology in	Electronics and Communication Engineering	on	Aman Kumar			
400	18EC8070	18U10598	Bachelor of Technology in	Electronics and Communication Engineering	on	Rathindra Nath Ghosh			
401	18EC8071	18U10600	Bachelor of Technology in	Electronics and Communication Engineering	on	Sangu Manideep Reddy			
402	18EC8072	18U10603	Bachelor of Technology in	Electronics and Communication Engineering	on	Sahaj Kumar Jha			
403	18EC8073	18U10605	Bachelor of Technology in	Electronics and Communication Engineering	on	Pranjal Mittal			
404	18EC8074	18U10611	Bachelor of Technology in	Electronics and Communication Engineering	on	Nim Lhamu Sherpa			
405	18EC8075	18U10621	Bachelor of Technology in	Electronics and Communication Engineering	on	Konda Chandra Sekhar			
406	18EC8076	18U10634	Bachelor of Technology in	Electronics and Communication Engineering	on	Vivek Gupta			
407	18EC8077	18U10690	Bachelor of Technology in	Electronics and Communication Engineering	on	Havila Delight Boddepalli			
408	18EC8078	18U10701	Bachelor of Technology in	Electronics and Communication Engineering	on	Rahul Mohata			
409	18EC8079	18U10702	Bachelor of Technology in	Electronics and Communication Engineering	on	Yamavaram Sree Shivani			
410	18EC8080	18U10714	Bachelor of Technology in	Electronics and Communication Engineering	on	Kapu Sharath Kumar Reddy			
411	18EC8081	18U10728	Bachelor of Technology in	Electronics and Communication Engineering	on	Johnny Living Ston.Jakkula			
412	18EC8082	18U10747	Bachelor of Technology in	Electronics and Communication Engineering	on	Urvashi			
413	18EC8083	18U10753	Bachelor of Technology in	Electronics and Communication Engineering	on	Abhishek Bose			
414	18EC8084	18U10763	Bachelor of Technology in	Electronics and Communication Engineering	on	Atul Kumar Tiwari			
415	18EC8085	18U10766	Bachelor of Technology in	Electronics and Communication Engineering	on	Saurabh Singh			
416	18EE8001	18U10009	Bachelor of Technology in	Electrical Engineering	on	Tanushree Dey			
417	18EE8002	18U10012	Bachelor of Technology in	Electrical Engineering	on	Doyel Maji			
418	18EE8003	18U10014	Bachelor of Technology in	Electrical Engineering	on	Prakash Kumar Hansda			

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419	18EE8004	18U10024	Bachelor of Technology in	Electrical Engineering	on	Parre Yashwanth			
420	18EE8005	18U10027	Bachelor of Technology in	Electrical Engineering	on	Kabyajyoti Biswas			
421	18EE8006	18U10036	Bachelor of Technology in	Electrical Engineering	on	Adhisha Roy			
422	18EE8007	18U10047	Bachelor of Technology in	Electrical Engineering	on	Shubham Jaiswal			
423	18EE8008	18U10050	Bachelor of Technology in	Electrical Engineering	on	Rahul Karmakar			
424	18EE8009	18U10065	Bachelor of Technology in	Electrical Engineering	on	Arnab Ari			
425	18EE8010	18U10074	Bachelor of Technology in	Electrical Engineering	on	Subhra Ranjan Karmakar			
426	18EE8011	18U10076	Bachelor of Technology in	Electrical Engineering	on	Soumyajit Saha			
427	18EE8012	18U10093	Bachelor of Technology in	Electrical Engineering	on	Vinita Singh			
428	18EE8013	18U10095	Bachelor of Technology in	Electrical Engineering	on	Biswajit Rout			
429	18EE8014	18U10098	Bachelor of Technology in	Electrical Engineering	on	Akash Kumar Gupta			
430	18EE8015	18U10103	Bachelor of Technology in	Electrical Engineering	on	Sujoy Sankar Ghosh			
431	18EE8016	18U10114	Bachelor of Technology in	Electrical Engineering	on	Lekh Ram			
432	18EE8017	18U10123	Bachelor of Technology in	Electrical Engineering	on	Rahul Kumar			
433	18EE8018	18U10125	Bachelor of Technology in	Electrical Engineering	on	Srijan Roy			
434	18EE8019	18U10130	Bachelor of Technology in	Electrical Engineering	on	Abhishek Malakar			
435	18EE8020	18U10156	Bachelor of Technology in	Electrical Engineering	on	Subhankar Datta			
436	18EE8021	18U10163	Bachelor of Technology in	Electrical Engineering	on	Shubham Banjare			
437	18EE8022	18U10173	Bachelor of Technology in	Electrical Engineering	on	Deepak			
438	18EE8023	18U10177	Bachelor of Technology in	Electrical Engineering	on	Sankhomala Hansda			
439	18EE8024	18U10183	Bachelor of Technology in	Electrical Engineering	on	Sayan Mondal			
440	18EE8025	18U10194	Bachelor of Technology in	Electrical Engineering	on	Sai Raghava Kailasa			

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441	18EE8026	18U10205	Bachelor of Technology in	Electrical Engineering	on	Sourav Chakraborty			
442	18EE8027	18U10210	Bachelor of Technology in	Electrical Engineering	on	Rochisnu Dutta			
443	18EE8028	18U10213	Bachelor of Technology in	Electrical Engineering	on	Suraj Kumar			
444	18EE8029	18U10215	Bachelor of Technology in	Electrical Engineering	on	Shubhajyoti Mondal			
445	18EE8030	18U10217	Bachelor of Technology in	Electrical Engineering	on	Srijit Majumder			
446	18EE8032	18U10230	Bachelor of Technology in	Electrical Engineering	on	Gorripati Divya Sai Priya			
447	18EE8033	18U10239	Bachelor of Technology in	Electrical Engineering	on	Maumita Basu			
448	18EE8034	18U10245	Bachelor of Technology in	Electrical Engineering	on	Nagaraboina Yashwanth			
449	18EE8036	18U10249	Bachelor of Technology in	Electrical Engineering	on	Ashif Ahafaj Laskar			
450	18EE8037	18U10257	Bachelor of Technology in	Electrical Engineering	on	Sakshi Paswan			
451	18EE8038	18U10258	Bachelor of Technology in	Electrical Engineering	on	Souvik Mandal			
452	18EE8039	18U10263	Bachelor of Technology in	Electrical Engineering	on	Rishabh Srivastava			
453	18EE8040	18U10265	Bachelor of Technology in	Electrical Engineering	on	Soumya Hembram			
454	18EE8041	18U10268	Bachelor of Technology in	Electrical Engineering	on	Kapish Luhariwala			
455	18EE8042	18U10282	Bachelor of Technology in	Electrical Engineering	on	Sandip Pramanik			
456	18EE8043	18U10312	Bachelor of Technology in	Electrical Engineering	on	Vishal Kumar			
457	18EE8044	18U10313	Bachelor of Technology in	Electrical Engineering	on	Yedala Aravind Kumar Reddy			
458	18EE8045	18U10315	Bachelor of Technology in	Electrical Engineering	on	Soumyadeep Saha			
459	18EE8046	18U10342	Bachelor of Technology in	Electrical Engineering	on	Agnivo Palit			
460	18EE8047	18U10348	Bachelor of Technology in	Electrical Engineering	on	Suchismita Nayak			
461	18EE8048	18U10354	Bachelor of Technology in	Electrical Engineering	on	Tamendra Kumar Sahu			
462	18EE8049	18U10356	Bachelor of Technology in	Electrical Engineering	on	Ajit Dhayal			

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463	18EE8050	18U10393	Bachelor of Technology in	Electrical Engineering	on	Anand Kharwar			
464	18EE8051	18U10405	Bachelor of Technology in	Electrical Engineering	on	Guntumani Jayaprakash Yadav			
465	18EE8052	18U10408	Bachelor of Technology in	Electrical Engineering	on	Kapil			
466	18EE8053	18U10412	Bachelor of Technology in	Electrical Engineering	on	Chavva Praneeth Kumar Reddy			
467	18EE8054	18U10415	Bachelor of Technology in	Electrical Engineering	on	Pradeep Kumar			
468	18EE8055	18U10418	Bachelor of Technology in	Electrical Engineering	on	Bheem Singh Meena			
469	18EE8056	18U10428	Bachelor of Technology in	Electrical Engineering	on	Nabha Venkata Naga Deepthi			
470	18EE8057	18U10461	Bachelor of Technology in	Electrical Engineering	on	Rathod Lipi Akanksha			
471	18EE8058	18U10464	Bachelor of Technology in	Electrical Engineering	on	Enugu Shashivardhan			
472	18EE8059	18U10481	Bachelor of Technology in	Electrical Engineering	on	Biraj Roy			
473	18EE8060	18U10502	Bachelor of Technology in	Electrical Engineering	on	Aman Singh			
474	18EE8061	18U10518	Bachelor of Technology in	Electrical Engineering	on	Shakti Tiwari			
475	18EE8062	18U10533	Bachelor of Technology in	Electrical Engineering	on	Madhura Ghosh			
476	18EE8063	18U10534	Bachelor of Technology in	Electrical Engineering	on	Koppadi Hemanth Narasimha Varma			
477	18EE8064	18U10545	Bachelor of Technology in	Electrical Engineering	on	Prataparao Sai Bhavya Teja			
478	18EE8065	18U10560	Bachelor of Technology in	Electrical Engineering	on	Sayak Acharya			
479	18EE8066	18U10563	Bachelor of Technology in	Electrical Engineering	on	Soham Samanta			
480	18EE8067	18U10564	Bachelor of Technology in	Electrical Engineering	on	Kakileti Sriram			
481	18EE8068	18U10567	Bachelor of Technology in	Electrical Engineering	on	Bhukya Vamshi			
482	18EE8069	18U10587	Bachelor of Technology in	Electrical Engineering	on	Immadisetty Lakshmi Bhagya Rajendra Kumar			
483	18EE8070	18U10595	Bachelor of Technology in	Electrical Engineering	on	Khushi Bansal			
484	18EE8071	18U10617	Bachelor of Technology in	Electrical Engineering	on	Rajkumar Halder			

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485	18EE8072	18U10636	Bachelor of Technology in	Electrical Engineering	on	Deepmoy Hazra			
486	18EE8073	18U10668	Bachelor of Technology in	Electrical Engineering	on	Piyush Satnaliwala			
487	18EE8074	18U10673	Bachelor of Technology in	Electrical Engineering	on	Ambika Biswas Neela			
488	18EE8075	18U10676	Bachelor of Technology in	Electrical Engineering	on	Devidas Panday			
489	18EE8076	18U10692	Bachelor of Technology in	Electrical Engineering	on	Vanamu Giridhar Kumar			
490	18EE8077	18U10694	Bachelor of Technology in	Electrical Engineering	on	Kumar Gourav			
491	18EE8078	18U10711	Bachelor of Technology in	Electrical Engineering	on	Anushka Agrawal			
492	18EE8079	18U10712	Bachelor of Technology in	Electrical Engineering	on	Prakhar Srivastava			
493	18EE8080	18U10722	Bachelor of Technology in	Electrical Engineering	on	Palavalasa Hima Sekhar			
494	18EE8081	18U10749	Bachelor of Technology in	Electrical Engineering	on	Shreya Marwaha			
495	18EE8082	18U10750	Bachelor of Technology in	Electrical Engineering	on	Akhilesh Karan Chaudhari			
496	18EE8083	18U10755	Bachelor of Technology in	Electrical Engineering	on	Shashikant Tiwari			
497	18EE8084	18U10757	Bachelor of Technology in	Electrical Engineering	on	Vishal Brahma			
498	18EE8085	18U10200	Bachelor of Technology in	Electrical Engineering	on	Balivada Sree Varsha			
499	17IT8022	17U10185	Bachelor of Technology in	Information Technology	on	Chiranjeet Gorai			
500	18ME8001	18U10003	Bachelor of Technology in	Mechanical Engineering	on	Dipayan Dalal			
501	18ME8002	18U10005	Bachelor of Technology in	Mechanical Engineering	on	Ripan Kundu			
502	18ME8003	18U10008	Bachelor of Technology in	Mechanical Engineering	on	Sucharu Rai			
503	18ME8004	18U10010	Bachelor of Technology in	Mechanical Engineering	on	Hridoy Halder			
504	18ME8005	18U10017	Bachelor of Technology in	Mechanical Engineering	on	Anunita Das			
505	18ME8006	18U10030	Bachelor of Technology in	Mechanical Engineering	on	Surojit Tudu			
506	18ME8007	18U10031	Bachelor of Technology in	Mechanical Engineering	on	Aman Agarwal			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
507	18ME8008	18U10037	Bachelor of Technology in	Mechanical Engineering	on	Suman Guin			
508	18ME8009	18U10041	Bachelor of Technology in	Mechanical Engineering	on	Mriganka Bagchi			
509	18ME8010	18U10044	Bachelor of Technology in	Mechanical Engineering	on	Anuragh Tamang			
510	18ME8011	18U10057	Bachelor of Technology in	Mechanical Engineering	on	Ananya Nath			
511	18ME8012	18U10068	Bachelor of Technology in	Mechanical Engineering	on	Argha Gayen			
512	18ME8013	18U10075	Bachelor of Technology in	Mechanical Engineering	on	Sourasish Kundu			
513	18ME8015	18U10081	Bachelor of Technology in	Mechanical Engineering	on	Allada Navdeep			
514	18ME8016	18U10088	Bachelor of Technology in	Mechanical Engineering	on	Rudraneel Sarkar			
515	18ME8017	18U10090	Bachelor of Technology in	Mechanical Engineering	on	Sheetal Tamang			
516	18ME8018	18U10094	Bachelor of Technology in	Mechanical Engineering	on	Jayanta Roy			
517	18ME8019	18U10096	Bachelor of Technology in	Mechanical Engineering	on	Anuvab Das			
518	18ME8020	18U10106	Bachelor of Technology in	Mechanical Engineering	on	Ankita Singha			
519	18ME8021	18U10107	Bachelor of Technology in	Mechanical Engineering	on	Harshit			
520	18ME8022	18U10108	Bachelor of Technology in	Mechanical Engineering	on	Debargha Ghosh			
521	18ME8023	18U10111	Bachelor of Technology in	Mechanical Engineering	on	Koushik Dutta			
522	18ME8024	18U10120	Bachelor of Technology in	Mechanical Engineering	on	Naveen Sah			
523	18ME8025	18U10121	Bachelor of Technology in	Mechanical Engineering	on	Tamoghna Basak			
524	18ME8026	18U10126	Bachelor of Technology in	Mechanical Engineering	on	Soumyadeep Saha			
525	18ME8027	18U10131	Bachelor of Technology in	Mechanical Engineering	on	Sumit Mishra			
526	18ME8028	18U10132	Bachelor of Technology in	Mechanical Engineering	on	Sanjana Roy			
527	18ME8029	18U10138	Bachelor of Technology in	Mechanical Engineering	on	Vanumu Khyatirmaye			
528	18ME8030	18U10140	Bachelor of Technology in	Mechanical Engineering	on	Subhrasnata Chakraborty			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
529	18ME8031	18U10141	Bachelor of Technology in	Mechanical Engineering	on	Himadri Dutta			
530	18ME8032	18U10143	Bachelor of Technology in	Mechanical Engineering	on	Amit Das Adhikary			
531	18ME8033	18U10145	Bachelor of Technology in	Mechanical Engineering	on	Kalyanam Vineeth Kumar			
532	18ME8034	18U10147	Bachelor of Technology in	Mechanical Engineering	on	Md. Meraj			
533	18ME8035	18U10155	Bachelor of Technology in	Mechanical Engineering	on	Anshu Yadav			
534	18ME8036	18U10158	Bachelor of Technology in	Mechanical Engineering	on	Theella Leela Shyam Kumar			
535	18ME8037	18U10160	Bachelor of Technology in	Mechanical Engineering	on	Rakesh Mandal			
536	18ME8038	18U10165	Bachelor of Technology in	Mechanical Engineering	on	Sudeep Saw			
537	18ME8039	18U10169	Bachelor of Technology in	Mechanical Engineering	on	Gaurav Bhagat			
538	18ME8040	18U10171	Bachelor of Technology in	Mechanical Engineering	on	Puja Kumari			
539	18ME8041	18U10176	Bachelor of Technology in	Mechanical Engineering	on	Kirti Kumari			
540	18ME8042	18U10180	Bachelor of Technology in	Mechanical Engineering	on	Akash Dandapat			
541	18ME8043	18U10181	Bachelor of Technology in	Mechanical Engineering	on	Unmish Bag			
542	18ME8044	18U10184	Bachelor of Technology in	Mechanical Engineering	on	Arko Sarkar			
543	18ME8045	18U10189	Bachelor of Technology in	Mechanical Engineering	on	Shivam			
544	18ME8046	18U10199	Bachelor of Technology in	Mechanical Engineering	on	Regidi Vijay Kumar			
545	18ME8048	18U10204	Bachelor of Technology in	Mechanical Engineering	on	Bandaru Vishnu Venkata Patrudu			
546	18ME8049	18U10206	Bachelor of Technology in	Mechanical Engineering	on	Amit Tiwari			
547	18ME8050	18U10209	Bachelor of Technology in	Mechanical Engineering	on	Bhavya Vashishtha			
548	18ME8051	18U10212	Bachelor of Technology in	Mechanical Engineering	on	Bheemarasetty Lakshmi Deepak			
549	18ME8052	18U10220	Bachelor of Technology in	Mechanical Engineering	on	Ankit Kumar Pandey			
550	18ME8053	18U10221	Bachelor of Technology in	Mechanical Engineering	on	Soumyadip Biswas			

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551	18ME8054	18U10225	Bachelor of Technology in	Mechanical Engineering	on	Subhendu Sekhar Bag			
552	18ME8055	18U10234	Bachelor of Technology in	Mechanical Engineering	on	Dhrubajyoti Kumar			
553	18ME8057	18U10241	Bachelor of Technology in	Mechanical Engineering	on	Gande Pranay Kumar			
554	18ME8058	18U10251	Bachelor of Technology in	Mechanical Engineering	on	Abhishek Singh			
555	18ME8059	18U10256	Bachelor of Technology in	Mechanical Engineering	on	Ariga Achyutha Sushanth			
556	18ME8060	18U10267	Bachelor of Technology in	Mechanical Engineering	on	Zidan Hossain			
557	18ME8061	18U10269	Bachelor of Technology in	Mechanical Engineering	on	Pratik Debnath			
558	18ME8062	18U10275	Bachelor of Technology in	Mechanical Engineering	on	Reddy Jyothendra Sai Durga Sankar			
559	18ME8063	18U10276	Bachelor of Technology in	Mechanical Engineering	on	Kaustuv Gandhi			
560	18ME8064	18U10278	Bachelor of Technology in	Mechanical Engineering	on	Boddu Siva Nageswa Rao			
561	18ME8066	18U10309	Bachelor of Technology in	Mechanical Engineering	on	Terli Girishma			
562	18ME8067	18U10321	Bachelor of Technology in	Mechanical Engineering	on	Rishab Verma			
563	18ME8068	18U10324	Bachelor of Technology in	Mechanical Engineering	on	Nuthangi Rahul			
564	18ME8069	18U10326	Bachelor of Technology in	Mechanical Engineering	on	Sonu Kumar			
565	18ME8070	18U10331	Bachelor of Technology in	Mechanical Engineering	on	Priyanshu			
566	18ME8072	18U10337	Bachelor of Technology in	Mechanical Engineering	on	Rohit Upreti			
567	18ME8073	18U10341	Bachelor of Technology in	Mechanical Engineering	on	Punya Chandra Arjya			
568	18ME8074	18U10347	Bachelor of Technology in	Mechanical Engineering	on	Vandakiya Abhishek			
569	18ME8075	18U10349	Bachelor of Technology in	Mechanical Engineering	on	S Rishi Chand			
570	18ME8076	18U10351	Bachelor of Technology in	Mechanical Engineering	on	Charugundla Manikanta Ganesh			
571	18ME8077	18U10357	Bachelor of Technology in	Mechanical Engineering	on	Anubhav			
572	18ME8078	18U10360	Bachelor of Technology in	Mechanical Engineering	on	Sourav Soo			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
573	18ME8079	18U10367	Bachelor of Technology in	Mechanical Engineering	on	Kokkiripati Neeharika			
574	18ME8080	18U10368	Bachelor of Technology in	Mechanical Engineering	on	Rishab Kumar			
575	18ME8081	18U10370	Bachelor of Technology in	Mechanical Engineering	on	Aakash Dey			
576	18ME8082	18U10380	Bachelor of Technology in	Mechanical Engineering	on	Vivek Kumar Shah			
577	18ME8083	18U10394	Bachelor of Technology in	Mechanical Engineering	on	Ryali Hyndavi			
578	18ME8084	18U10398	Bachelor of Technology in	Mechanical Engineering	on	Debabrata Moi			
579	18ME8085	18U10411	Bachelor of Technology in	Mechanical Engineering	on	Salihundam Simhakoushik			
580	18ME8086	18U10413	Bachelor of Technology in	Mechanical Engineering	on	Galla Tharun Kumar			
581	18ME8087	18U10417	Bachelor of Technology in	Mechanical Engineering	on	Shreyashkar Lal Sahu			
582	18ME8088	18U10426	Bachelor of Technology in	Mechanical Engineering	on	Kalpam Sushith			
583	18ME8089	18U10430	Bachelor of Technology in	Mechanical Engineering	on	Vraj Kartik Desai			
584	18ME8090	18U10431	Bachelor of Technology in	Mechanical Engineering	on	Mayank Dandwani			
585	18ME8091	18U10435	Bachelor of Technology in	Mechanical Engineering	on	Karumajji Soma Sundar			
586	18ME8092	18U10437	Bachelor of Technology in	Mechanical Engineering	on	Kuddapu Ashish Kumar			
587	18ME8093	18U10449	Bachelor of Technology in	Mechanical Engineering	on	Shubham Agarwal			
588	18ME8094	18U10450	Bachelor of Technology in	Mechanical Engineering	on	Dasam Prudhvi			
589	18ME8095	18U10451	Bachelor of Technology in	Mechanical Engineering	on	Chetan Gupta			
590	18ME8096	18U10460	Bachelor of Technology in	Mechanical Engineering	on	Bighnesh Mohanty			
591	18ME8097	18U10465	Bachelor of Technology in	Mechanical Engineering	on	Thamarbha Jeevitha			
592	18ME8098	18U10469	Bachelor of Technology in	Mechanical Engineering	on	Vivek Kumar			
593	18ME8099	18U10470	Bachelor of Technology in	Mechanical Engineering	on	Sachin Rawat			
594	18ME8100	18U10474	Bachelor of Technology in	Mechanical Engineering	on	Jovin Litto			

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595	18ME8101	18U10477	Bachelor of Technology in	Mechanical Engineering	on	Soumik Kumar Hazra			
596	18ME8102	18U10479	Bachelor of Technology in	Mechanical Engineering	on	Soumyajit Ganguly			
597	18ME8103	18U10490	Bachelor of Technology in	Mechanical Engineering	on	Ankita Mishra			
598	18ME8104	18U10492	Bachelor of Technology in	Mechanical Engineering	on	Suraj Kumar Sahoo			
599	18ME8105	18U10520	Bachelor of Technology in	Mechanical Engineering	on	Akash Sharma			
600	18ME8106	18U10524	Bachelor of Technology in	Mechanical Engineering	on	Koka Sai Saketh			
601	18ME8107	18U10525	Bachelor of Technology in	Mechanical Engineering	on	V Vishesh			
602	18ME8108	18U10526	Bachelor of Technology in	Mechanical Engineering	on	Rangeet Hait			
603	18ME8109	18U10532	Bachelor of Technology in	Mechanical Engineering	on	Adrija Biswas			
604	18ME8110	18U10535	Bachelor of Technology in	Mechanical Engineering	on	Rittick Purkait			
605	18ME8111	18U10539	Bachelor of Technology in	Mechanical Engineering	on	Souvik Bose			
606	18ME8112	18U10542	Bachelor of Technology in	Mechanical Engineering	on	Soumyadeep Mondal			
607	18ME8113	18U10546	Bachelor of Technology in	Mechanical Engineering	on	Arabelli Sriram Reddy			
608	18ME8114	18U10552	Bachelor of Technology in	Mechanical Engineering	on	Madhav Jha			
609	18ME8116	18U10557	Bachelor of Technology in	Mechanical Engineering	on	Sauhardo Roy			
610	18ME8117	18U10568	Bachelor of Technology in	Mechanical Engineering	on	Rik Dasgupta			
611	18ME8118	18U10570	Bachelor of Technology in	Mechanical Engineering	on	Khandavalli Dinesh			
612	18ME8119	18U10580	Bachelor of Technology in	Mechanical Engineering	on	Mukul Anand			
613	18ME8120	18U10588	Bachelor of Technology in	Mechanical Engineering	on	R Pavan Kumar			
614	18ME8121	18U10590	Bachelor of Technology in	Mechanical Engineering	on	Arnab Roy Chowdhury			
615	18ME8122	18U10591	Bachelor of Technology in	Mechanical Engineering	on	Anushka Sen			
616	18ME8123	18U10593	Bachelor of Technology in	Mechanical Engineering	on	Aryan Kanu			

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617	18ME8124	18U10608	Bachelor of Technology in	Mechanical Engineering	on	Immandi Pavan Preetham			
618	18ME8125	18U10612	Bachelor of Technology in	Mechanical Engineering	on	Malyadeep Bhattacharya			
619	18ME8127	18U10623	Bachelor of Technology in	Mechanical Engineering	on	Somarya Bhattacharyya			
620	18ME8128	18U10624	Bachelor of Technology in	Mechanical Engineering	on	Ashis Srivastava			
621	18ME8129	18U10625	Bachelor of Technology in	Mechanical Engineering	on	Siddhant S Barman			
622	18ME8130	18U10631	Bachelor of Technology in	Mechanical Engineering	on	Aditya Kumar Chaubey			
623	18ME8131	18U10638	Bachelor of Technology in	Mechanical Engineering	on	Ankan Chakraborty			
624	18ME8132	18U10650	Bachelor of Technology in	Mechanical Engineering	on	Ishika Chowdhury			
625	18ME8133	18U10654	Bachelor of Technology in	Mechanical Engineering	on	Shubhangee			
626	18ME8134	18U10655	Bachelor of Technology in	Mechanical Engineering	on	Apurba Mondal			
627	18ME8135	18U10656	Bachelor of Technology in	Mechanical Engineering	on	Dabbiru Rohit Kumar			
628	18ME8136	18U10659	Bachelor of Technology in	Mechanical Engineering	on	Kiran P Abraham			
629	18ME8137	18U10662	Bachelor of Technology in	Mechanical Engineering	on	Mohith Vardhan Baswa			
630	18ME8138	18U10667	Bachelor of Technology in	Mechanical Engineering	on	Shaik Gouse Mastan			
631	18ME8139	18U10671	Bachelor of Technology in	Mechanical Engineering	on	Divyanshu Bajpai			
632	18ME8140	18U10675	Bachelor of Technology in	Mechanical Engineering	on	A S M Norul Amin			
633	18ME8141	18U10678	Bachelor of Technology in	Mechanical Engineering	on	Shivam Gangwar			
634	18ME8142	18U10679	Bachelor of Technology in	Mechanical Engineering	on	Pachava Lohitha			
635	18ME8143	18U10684	Bachelor of Technology in	Mechanical Engineering	on	Gagan Prasad Gautam			
636	18ME8144	18U10715	Bachelor of Technology in	Mechanical Engineering	on	Ankit Lunia			
637	18ME8145	18U10716	Bachelor of Technology in	Mechanical Engineering	on	Shivam			
638	18ME8146	18U10717	Bachelor of Technology in	Mechanical Engineering	on	Mekala Purushottam			

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639	18ME8147	18U10720	Bachelor of Technology in	Mechanical Engineering	on	Piyush Yadav			
640	18ME8149	18U10724	Bachelor of Technology in	Mechanical Engineering	on	Nagireddi Mounica			
641	18ME8150	18U10725	Bachelor of Technology in	Mechanical Engineering	on	Vankudoth Pranay			
642	18ME8152	18U10741	Bachelor of Technology in	Mechanical Engineering	on	Roshan Kumar			
643	18ME8153	18U10745	Bachelor of Technology in	Mechanical Engineering	on	Snigdha Behera			
644	18ME8154	18U10752	Bachelor of Technology in	Mechanical Engineering	on	Aadarsh Kumar Mishra			
645	18ME8156	18U10758	Bachelor of Technology in	Mechanical Engineering	on	Tripti Kona Biswas			
646	18ME8157	18U10186	Bachelor of Technology in	Mechanical Engineering	on	Nilabro Saha			
647	18ME8158	18U10193	Bachelor of Technology in	Mechanical Engineering	on	Sanniva Bhattacharjee			
648	11/ME/118	20110520	Bachelor of Technology in	Mechanical Engineering	on	Biswanath Bar			
649	11/ME/112	20110484	Bachelor of Technology in	Mechanical Engineering	on	Sivanto Dutta			
650	11/ME/82	20110333	Bachelor of Technology in	Mechanical Engineering	on	Plaban Roy			
651	17MM8021	17U10406	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Prince Kumar			
652	18MM8001	18U10045	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Lokesh Singh			
653	18MM8002	18U10064	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Khansa Shahnawaz			
654	18MM8003	18U10109	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Anand Yadav			
655	18MM8004	18U10122	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Soumen Basak			
656	18MM8005	18U10136	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Subham Kumar Agarwal			
657	18MM8006	18U10175	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Aman Pr Nonia			
658	18MM8008	18U10216	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Pallavi Ranjan			
659	18MM8009	18U10224	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sarbojit Majumder			
660	18MM8010	18U10229	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Prasun Kumar Paul			

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661	18MM8011	18U10266	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Bhupesh Yadav			
662	18MM8012	18U10271	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Lakshmi Nagarjuna Malla			
663	18MM8013	18U10273	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Atish Das			
664	18MM8014	18U10285	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Preetam Raj			
665	18MM8015	18U10290	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Siddhant Shikhar Gupta			
666	18MM8016	18U10293	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Santosh Hembram			
667	18MM8017	18U10299	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Shivendra Pratap Singh			
668	18MM8018	18U10304	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Durgesh Kumar Jha			
669	18MM8019	18U10311	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Syed Abdur Rahman			
670	18MM8020	18U10346	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Tapojyoti Mohanta			
671	18MM8021	18U10355	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Choppari Srileela			
672	18MM8022	18U10374	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Unmesh Roy			
673	18MM8023	18U10375	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Andugula Ashish Babu			
674	18MM8024	18U10392	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Rabin Mondal			
675	18MM8025	18U10403	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Namrata Majumdar			
676	18MM8026	18U10420	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kailash Thalore			
677	18MM8027	18U10432	Bachelor of Technology in	Metallurgical and Materials Engineering	on	P Sravan			
678	18MM8028	18U10440	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Jissnu Kundu			
679	18MM8029	18U10444	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Karan Kumar Singh			
680	18MM8030	18U10462	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Samareddy Sailaja			
681	18MM8031	18U10468	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kanneti Eswar Reddy			
682	18MM8032	18U10495	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Malobika Biswas			
683	18MM8033	18U10499	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Debakshi Gupta			

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684	18MM8034	18U10500	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Trishikha Saha			
685	18MM8035	18U10510	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Konathala S M Aeyshovardhan			
686	18MM8036	18U10540	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Pullagura Manoj Kumar			
687	18MM8037	18U10551	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sonu Kumar Mishra			
688	18MM8038	18U10565	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kalali Lingam Goud			
689	18MM8039	18U10566	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Karam Krishna Chaithanya			
690	18MM8040	18U10573	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Ankit Adak			
691	18MM8041	18U10574	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Md Shayeeque Alam			
692	18MM8042	18U10577	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Arpan Ghosh			
693	18MM8043	18U10578	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Rohit Kumar Gangopadhyay			
694	18MM8045	18U10594	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Niharika			
695	18MM8046	18U10599	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sharbashis Das			
696	18MM8047	18U10629	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sarathi Dey			
697	18MM8048	18U10652	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Karri Kodhanda Dhanunjay Pavan			
698	18MM8049	18U10680	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Renuka Nag			
699	18MM8050	18U10685	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Aman Verma			
700	18MM8051	18U10691	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Malla Rohith			
701	18MM8052	18U10697	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Nitesh Saini			
702	18MM8053	18U10700	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Ajit Kumar			
703	18MM8054	18U10704	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Jagadish Mahata			
704	18MM8055	18U10707	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Atharva Vilas Vyawahare			
705	18MM8056	18U10719	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sunil Kumar			
706	18MM8057	18U10726	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Gompa Kiran Kumar			

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707	18MM8058	18U10729	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kasimalla Prathyusha			
708	18MM8059	18U10736	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Gajraj Gurjar			
709	18MM8060	18U10739	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Rinku Hembrom			
710	18MM8061	18U10767	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Snigdha Chakraborty			
711	17BT1002	17U10227	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Jai Inder Veer Singh Kang			
712	17BT1004	17U10572	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Tiasha Ghosh			
713	17BT1005	17U10577	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Rudranil Das			
714	17BT1006	17U10635	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Abhishek Mishra			
715	17BT1007	17U10741	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Vikash Kumar			
716	17CH1002	17U10638	Bachelor of Technology (under Dual Degree program)	Chemical Engineering	on	Sudeshna Gun			
717	17CH1003	17U10643	Bachelor of Technology (under Dual Degree program)	Chemical Engineering	on	Vineet Kumar			
718	17CH1004	17U10673	Bachelor of Technology (under Dual Degree program)	Chemical Engineering	on	Gulshan Kumar			
719	17BT1002	17U10227	Master of Technology (under Dual Degree program) in	Biotechnology	on	Jai Inder Veer Singh Kang			
720	17BT1004	17U10572	Master of Technology (under Dual Degree program) in	Biotechnology	on	Tiasha Ghosh			
721	17BT1005	17U10577	Master of Technology (under Dual Degree program) in	Biotechnology	on	Rudranil Das			
722	17BT1006	17U10635	Master of Technology (under Dual Degree program) in	Biotechnology	on	Abhishek Mishra			
723	17BT1007	17U10741	Master of Technology (under Dual Degree program) in	Biotechnology	on	Vikash Kumar			
724	17CH1002	17U10638	Master of Technology (under Dual Degree program) in	Chemical Engineering	on	Sudeshna Gun			
725	17CH1003	17U10643	Master of Technology (under Dual Degree program) in	Chemical Engineering	on	Vineet Kumar			
726	17CH1004	17U10673	Master of Technology (under Dual Degree program) in	Chemical Engineering	on	Gulshan Kumar			
727	17CY1002	17U10308	Integrated Master of Science in	Chemistry	on	Subhradeep Barman			
728	17CY1003	17U10611	Integrated Master of Science in	Chemistry	on	Agniva Mukherjee			
729	17CY1004	17U10636	Integrated Master of Science in	Chemistry	on	Ratan Singh			

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LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
730	17CY1006	17U10681	Integrated Master of Science in	Chemistry	on	Mayank Meena			
731	17CY1008	17U10689	Integrated Master of Science in	Chemistry	on	Manoj Singh			
732	17CY1009	17U10712	Integrated Master of Science in	Chemistry	on	Ritam Swarnakar			
733	17CY1010	17U10720	Integrated Master of Science in	Chemistry	on	Piyush Tiwari			
734	17CY1013	17U10760	Integrated Master of Science in	Chemistry	on	Saurabh Kumar			

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LIST OF B.TECH INSTITUTE GOLD MEDAL RECIPIENTS

Sl No	Roll No	Reg. No.	Awards	to	in recognition of being First in	in	in the academic session ending	Photograph	Remarks
1	18BT8009	18U10172	Institute Gold Medal	Ahana Sarkar	Bachelor of Technology in	Biotechnology	June 2022		
2	18CE8052	18U10618	Institute Gold Medal	Sayantan Bishnu	Bachelor of Technology in	Civil Engineering	June 2022		
3	18CH8019	18U10270	Institute Gold Medal	Saumyajeet Mukherjee	Bachelor of Technology in	Chemical Engineering	June 2022		
4	18CS8138	18U10514	Institute Gold Medal	Abhishek Gupta	Bachelor of Technology in	Computer Science and Engineering	June 2022		
5	18EC8055	18U10423	Institute Gold Medal	Kondapi V S Krishna Praveen	Bachelor of Technology in	Electronics and Communication	June 2022		
6	18EE8085	18U10200	Institute Gold Medal	Balivada Sree Varsha	Bachelor of Technology in	Electrical Engineering	June 2022		
7	18ME8077	18U10357	Institute Gold Medal	Anubhav	Bachelor of Technology in	Mechanical Engineering	June 2022		
8	18MM8019	18U10311	Institute Gold Medal	Syed Abdur Rahman	Bachelor of Technology in	Metallurgical and Materials	June 2022		

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LIST OF DUAL DEGREE AND INTEGRATED M.Sc INSTITUTE GOLD MEDAL RECIPIENTS

Sl No	Roll No	Reg. No.	Awards	to	in recognition of being First in	in	in the academic session ending	Photograph	Remarks
1	17BT1004	17U10572	Institute Gold Medal	Tiasha Ghosh	Master of Technology (under Dual Degree program) in	Biotechnology	June 2022		
2	17CH1002	17U10638	Institute Gold Medal	Sudeshna Gun	Master of Technology (under Dual Degree program) in	Chemical Engineering	June 2022		
3	17CY1002	17U10308	Institute Gold Medal	Subhradeep Barman	Integrated Master of Science in	Chemistry	June 2022		

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LIST OF B.TECH ENDOWMENT GOLD MEDAL RECIPIENTS

Sl No	Roll No	Reg. No.	hereby awards	to		Photograph	Remarks
1	18BT8009	18U10172	D. V. Sitabai Memorial Gold Medal	Ahana Sarkar	for securing highest CGPA in Bachelor of Technology in the academic session ending in June 2022		
2	18BT8009	18U10172	Parpatidevi Chandumal Memorial Gold Medal	Ahana Sarkar	for scholastic excellence amount girl students in Bachelor of Technology in the academic session ending in June 2022		
3	18MM8019	18U10311	Smt. Tarulata Sinha Memorial Gold Medal	Syed Abdur Rahman	for securing highest CGPA in Bachelor of Technology in Metallurgical and Materials Engineering in the academic session ending in June 2022		

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Annexure - I
UGAC and PGAC (29/07/2022)

18TH CONVOCATION
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LIST OF POST GRADUATE DEGREE RECIPIENTS

Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
1	20BT4101	20P10045	Master of Technology	in Biotechnology	(Department of Biotechnology)	Shreyayukta Chakraborty	
2	20BT4102	20P10053	Master of Technology	in Biotechnology	(Department of Biotechnology)	Abhineet Banerjee	
3	20BT4103	20P10112	Master of Technology	in Biotechnology	(Department of Biotechnology)	Shalini Das	
4	20BT4104	20P10187	Master of Technology	in Biotechnology	(Department of Biotechnology)	Shatakshi Bhattacherjee	
5	20BT4105	20P10224	Master of Technology	in Biotechnology	(Department of Biotechnology)	Nivruthi Sasi	
6	20BT4106	20P10247	Master of Technology	in Biotechnology	(Department of Biotechnology)	Monojit Kamilya	
7	20BT4107	20P10271	Master of Technology	in Biotechnology	(Department of Biotechnology)	Roshan Jaiswal	
8	20BT4108	20P10325	Master of Technology	in Biotechnology	(Department of Biotechnology)	Ashwini Ramdas Santape	
9	20BT4109	20P10345	Master of Technology	in Biotechnology	(Department of Biotechnology)	Kanmani M	
10	20BT4110	20P10389	Master of Technology	in Biotechnology	(Department of Biotechnology)	Kheerthana R	
11	20CE4101	20P10029	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Kundan Kumar Mandal	
12	20CE4102	20P10038	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Nirabhra Agrawal	
13	20CE4103	20P10078	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Sourabh Shrivastava	
14	20CE4104	20P10091	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Niladri Biswas	
15	20CE4105	20P10106	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Umesh Gupta	
16	20CE4106	20P10107	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Bajrabahu Dhananjay Narayan Deo	
17	20CE4107	20P10156	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Sudarshan Barve	
18	20CE4108	20P10159	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Vikash Kumar Pandey	
19	20CE4109	20P10161	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Loka Venkata Krishna Reddy	
20	20CE4110	20P10174	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Nikesh Sharma	
21	20CE4111	20P10175	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Mohammed Mumtaj	
22	20CE4112	20P10177	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Mohammad Yasir Mohammad Hasan Shaikh	
23	20CE4113	20P10189	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Manoranjan Roy	
24	20CE4114	20P10334	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Jalla Sandeep Kumar Reddy	
25	20CE4115	20P10346	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Maroju Ranjith Teja	
26	20CE4116	20P10351	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Gautam Kumar	
27	20CE4117	20P10413	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Mukul Raj Abhishek	
28	20CE4119	20P10456	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Rohit Kumar	
29	20CE4201	20P10054	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Soumen Purkayastha	
30	20CE4202	20P10072	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Anindya Sundar	
31	20CE4203	20P10077	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Ashish Kumar	
32	20CE4204	20P10083	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Abdul Waris	
33	20CE4205	20P10088	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Kumar Saurabh	
34	20CE4206	20P10090	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Rishabh Kumar	
35	20CE4207	20P10141	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Sanjay Kumar	
36	20CE4208	20P10149	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Sourav Bhattacharjee	
37	20CE4209	20P10178	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Rahul Raman	
38	20CE4210	20P10194	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Gyajangi Harikrishna	
39	20CE4211	20P10200	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Souvik Mondal	
40	20CE4213	20P10257	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Viveka Nand	
41	20CE4214	20P10293	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Devireddy Venu Gopal Reddy	
42	20CE4215	20P10299	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Rajesh Nandi	
43	20CE4216	20P10314	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Vikash Kumar	
44	20CE4217	20P10342	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Shivam Dhar Dwivedi	
45	20CE4218	20P10356	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Anupa Chakraborty	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
46	20CH4102	20P10436	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Anekella Sreelekha Reddy	
47	20CH4103	20P10438	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Saira Mohanty	
48	20CH4104	20P10439	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Ekambara Samal	
49	20CH4105	20P10440	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Abhishek Roy	
50	20CH4106	20P10443	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Debasish Mahato	
51	20CH4107	20P10445	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Payal Das	
52	20CH4108	20P10446	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Shubham Kumar	
53	20CH4109	20P10448	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Swasti Ghosh	
54	20CH4110	20P10449	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Arghya Singha Mahapatra	
55	20CH4111	20P10451	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Deepu Kumar Jha	
56	20CH4112	20P10452	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Nikitha Lohia	
57	20CH4113	20P10455	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Nilotpal Bora	
58	20CS4101	20P10030	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Jaya Krishna Bhonagiri	
59	20CS4102	20P10036	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Satyabrata Jena	
60	20CS4103	20P10037	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Arghya Bandyopadhyay	
61	20CS4104	20P10042	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Akanksha	
62	20CS4105	20P10056	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Saikumar Poosala	
63	20CS4106	20P10058	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Priyanka Gautam	
64	20CS4107	20P10067	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Abhijeet Kumar	
65	20CS4108	20P10070	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nishkarsh Patel	
66	20CS4109	20P10081	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Subrata Maity	
67	20CS4110	20P10082	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Abhijit Saha	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
68	20CS4111	20P10089	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Debasish Kalita	
69	20CS4112	20P10094	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shailabh Suman	
70	20CS4113	20P10096	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Alka Rani	
71	20CS4115	20P10116	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Oneil Michael Mascarenhas	
72	20CS4116	20P10117	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Saloni Vashisth	
73	20CS4117	20P10118	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Karthik S	
74	20CS4118	20P10134	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Pranshu Sharma	
75	20CS4119	20P10136	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shubham Verma	
76	20CS4120	20P10137	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Salini Kashyap	
77	20CS4121	20P10138	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Saurabh Kumar Jaiswal	
78	20CS4122	20P10142	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aman Kumar	
79	20CS4123	20P10145	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Manoj Kumar	
80	20CS4124	20P10162	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Jayant Kumar	
81	20CS4125	20P10166	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Birju Shaw	
82	20CS4127	20P10180	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Prashant Dubey	
83	20CS4130	20P10190	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Palzang Norgay Bhutia	
84	20CS4131	20P10197	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Pragati Ghansham Dumre	
85	20CS4132	20P10198	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Surya Ravi Sable	
86	20CS4133	20P10215	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Arnab Chatterjee	
87	20CS4134	20P10221	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Priyanka Bansal	
88	20CS4136	20P10229	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Bidyut Bikash Goswami	
89	20CS4137	20P10230	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Yash Makwana	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
90	20CS4138	20P10231	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Ankita Das	
91	20CS4139	20P10238	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Debashish Naik	
92	20CS4141	20P10248	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nirmal Sonal	
93	20CS4142	20P10254	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Anisha Mehnaaz Mallick	
94	20CS4143	20P10256	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aditya Kumar	
95	20CS4145	20P10270	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Bikash Basfore	
96	20CS4146	20P10274	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Anurag Dutt	
97	20CS4147	20P10287	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Roshan Kumar	
98	20CS4148	20P10288	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Amareshwar Chakravarti	
99	20CS4149	20P10289	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Rudra Narayan Mondal	
100	20CS4150	20P10297	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Vijaya Laxmi Yadav	
101	20CS4151	20P10298	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Himanshu Sirohi	
102	20CS4152	20P10303	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Md Faizan Reza	
103	20CS4153	20P10320	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aditya Mohata	
104	20CS4154	20P10323	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Ankita Kumari	
105	20CS4155	20P10326	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Apurva Verma	
106	20CS4156	20P10327	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Kailash Jamuda	
107	20CS4157	20P10329	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Md Aadil	
108	20CS4158	20P10331	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Bandana Sahu	
109	20CS4159	20P10332	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shekhar Chauhan	
110	20CS4161	20P10337	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Rohan Bhagat	
111	20CS4162	20P10357	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Krishna Murti	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
112	20CS4163	20P10361	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Subhojoy Dey	
113	20CS4164	20P10368	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Priyoshma Sonkar	
114	20CS4165	20P10371	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Utkarsh Shukla	
115	20CS4166	20P10372	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Namrata Khadanga	
116	20CS4167	20P10380	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Madhu Kumari	
117	20CS4168	20P10383	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Vinay Kumar	
118	20CS4169	20P10387	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Sudipta Kumar Nath	
119	20CS4170	20P10392	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nandkishore Prakashrao Nangre	
120	20CS4173	20P10402	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nirmal Kumar Majhi	
121	20CS4174	20P10410	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Vikash Kumar	
122	20CS4175	20P10418	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Sayantan Mukherjee	
123	20CS4176	20P10421	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aishwarya Manishi	
124	20CS4177	20P10432	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shivang Agarwal	
125	20EC4101	20P10050	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Ranjeet Kishore Bal	
126	20EC4102	20P10061	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Samyat Sahu	
127	20EC4103	20P10075	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Jai Sharan Shukla	
128	20EC4104	20P10100	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Shruti Mary Mathew	
129	20EC4105	20P10129	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Anil Kumar Padhy	
130	20EC4106	20P10155	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Sk Riaz Bin Rafique	
131	20EC4107	20P10160	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Hritwika Sarkar	
132	20EC4108	20P10184	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Neha Pallavi	
133	20EC4109	20P10214	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Jagannath Kundu	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
134	20EC4110	20P10251	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Akhil Kumar Kv	
135	20EC4111	20P10291	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Moumita Mondal	
136	20EC4112	20P10308	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Rishika Kar	
137	20EC4113	20P10353	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Ajay Kumar	
138	20EC4115	20P10370	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Nishat Fatma	
139	20EC4116	20P10382	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Sravani Kalakonda	
140	19EC4201	19P10001	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Varsha Kumari Saw	
141	20EC4201	20P10040	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Suraj Singh Rajput	
142	20EC4202	20P10052	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Bhagyashree Trilokdas Goje	
143	20EC4203	20P10104	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Debabrata Sahu	
144	20EC4204	20P10123	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Pavan Suresh Ambhore	
145	20EC4205	20P10125	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Jeevan Tulashiram Thakare	
146	20EC4206	20P10128	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Pallav Punit Chawda	
147	20EC4207	20P10146	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Deepak Kumar	
148	20EC4209	20P10168	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Shubham Kumar Satpute	
149	20EC4210	20P10192	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Ankita Motiram Bat	
150	20EC4211	20P10207	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Laukik Mohan Chavan	
151	20EC4212	20P10217	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Mayank Kumar Tarai	
152	20EC4213	20P10232	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Bishnudev Ojha	
153	20EC4214	20P10258	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Kavita Ghanshyam Saroj	
154	20EC4215	20P10338	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Yogesh Prasad Dewangan	
155	20EC4216	20P10341	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Chandra Shekhar Singh	

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156	20EC4217	20P10349	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Sudhanshu Vinayak Gulavani	
157	20EC4218	20P10359	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Nandita Prodyot Nandi	
158	20EC4219	20P10425	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Janhavi Avinash Sane	
159	20EE4101	20P10064	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Sabarna Das	
160	20EE4103	20P10095	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Rachana Rajamma Kaki	
161	20EE4104	20P10103	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Mylagani Manicharan	
162	20EE4106	20P10151	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Rajesh Verma	
163	20EE4107	20P10157	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Rohan Mukherjee	
164	20EE4109	20P10171	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Arindam Chowdhury	
165	20EE4110	20P10202	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Nidhi R	
166	20EE4112	20P10228	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Arpan Naskar	
167	20EE4113	20P10275	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Bikash Kumar Parida	
168	20EE4115	20P10340	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Sayantan Chatterjee	
169	20EE4116	20P10355	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Vishvajeet Tiwari	
170	20EE4118	20P10395	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Neha Kumari	
171	20EE4119	20P10406	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Satyajeet	
172	19EE4201	19P10006	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Ankita Vishwakarma	
173	19EE4203	19P10052	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Priya Malhotra	
174	19EE4211	19P10254	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Jayashree Biswas	
175	20EE4201	20P10031	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Navneet Maddhesiya	
176	20EE4202	20P10033	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Abhishek Rohit	
177	20EE4204	20P10071	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Suman Karmakar	

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178	20EE4205	20P10098	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Akhilesh Bharti	
179	20EE4206	20P10109	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Subhajit Das	
180	20EE4208	20P10167	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Rishabh Raj	
181	20EE4209	20P10173	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Aditya Prakash	
182	20EE4210	20P10176	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Sumit Saha	
183	20EE4211	20P10196	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Sivanatha Reddy Nandyala	
184	20EE4212	20P10273	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Vikas Pandey	
185	20EE4213	20P10290	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Sourav Kumar Sahoo	
186	20EE4214	20P10294	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Abhishek Maji	
187	20EE4215	20P10295	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Bikram Ram	
188	20EE4216	20P10347	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Kalyani Mamidi	
189	20EE4217	20P10348	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Bhanu Prakash Goddugorla	
190	20EE4218	20P10360	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Badal Pandit	
191	20EE4219	20P10394	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Jaya Ram Pilla	
192	20ES4101	20P10051	Master of Technology	in Environmental Science and Technology		Dewashish	
193	20ES4102	20P10066	Master of Technology	in Environmental Science and Technology		Yerramshetti Nikhil Sagar	
194	20ES4103	20P10147	Master of Technology	in Environmental Science and Technology		Sandeep Kumar	
195	20ES4104	20P10148	Master of Technology	in Environmental Science and Technology		Adhirath Kumar	
196	20ES4105	20P10172	Master of Technology	in Environmental Science and Technology		Susant Kumar Sahoo	
197	20ES4106	20P10213	Master of Technology	in Environmental Science and Technology		Anamika Tiwari	
198	20ES4107	20P10262	Master of Technology	in Environmental Science and Technology		Nisha Kumari	
199	20ES4108	20P10267	Master of Technology	in Environmental Science and Technology		Santosh Kumar	
200	20ES4109	20P10269	Master of Technology	in Environmental Science and Technology		Rahul Jha	
201	20ES4110	20P10277	Master of Technology	in Environmental Science and Technology		Nagendra Kumar Jilagam	
202	20ES4111	20P10278	Master of Technology	in Environmental Science and Technology		Vinod Kumar Saket	
203	20ES4112	20P10282	Master of Technology	in Environmental Science and Technology		Shardul Srivastava	
204	20ES4113	20P10309	Master of Technology	in Environmental Science and Technology		Kurupati Lokesh	
205	20ES4114	20P10336	Master of Technology	in Environmental Science and Technology		Debasmita Datta	
206	20ES4115	20P10376	Master of Technology	in Environmental Science and Technology		Swapnanil Saha	
207	20ES4116	20P10390	Master of Technology	in Environmental Science and Technology		Shivam Jaiswal	
208	20ES4118	20P10422	Master of Technology	in Environmental Science and Technology		Marrapu Narendra Kumar	

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209	20MA4101	20P10043	Master of Technology	in Operations Research	(Department of Mathematics)	Vickey Kumar	
210	20MA4102	20P10048	Master of Technology	in Operations Research	(Department of Mathematics)	Likhil Dondapaty	
211	20MA4103	20P10073	Master of Technology	in Operations Research	(Department of Mathematics)	Manikanta Narayanasetti	
212	20MA4104	20P10074	Master of Technology	in Operations Research	(Department of Mathematics)	Biswanath Singha	
213	20MA4105	20P10086	Master of Technology	in Operations Research	(Department of Mathematics)	Sanju Kushwaha	
214	20MA4106	20P10101	Master of Technology	in Operations Research	(Department of Mathematics)	Binod Kumar Shaw	
215	20MA4107	20P10218	Master of Technology	in Operations Research	(Department of Mathematics)	Alok Kumar Pandey	
216	20MA4109	20P10279	Master of Technology	in Operations Research	(Department of Mathematics)	Sarvesh Kumar Yadav	
217	20MA4110	20P10354	Master of Technology	in Operations Research	(Department of Mathematics)	Pathade Akshay Shivaji	
218	20MA4111	20P10384	Master of Technology	in Operations Research	(Department of Mathematics)	Himanshu Pandey	
219	20MA4112	20P10398	Master of Technology	in Operations Research	(Department of Mathematics)	Km Shivani Sharma	
220	20MA4115	20P10420	Master of Technology	in Operations Research	(Department of Mathematics)	Nikhitha Polkampally	
221	20MA4116	20P10429	Master of Technology	in Operations Research	(Department of Mathematics)	Priya Bharti	
222	20ME4101	20P10034	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Boddepalli Anil Kumar	
223	20ME4102	20P10044	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rajendra Kumar	
224	20ME4103	20P10065	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Sanju Mondal	
225	20ME4104	20P10069	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Gangineni Sandeep	
226	20ME4105	20P10093	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Pritam Sutradhar	
227	20ME4106	20P10099	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Gadigatla Harish	
228	20ME4107	20P10114	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rahul Kumar Singh	
229	20ME4108	20P10121	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Atul Patel	
230	20ME4109	20P10185	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Sai Jayaram Boggala	
231	20ME4110	20P10188	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Ponnada Durga Prasad	
232	20ME4111	20P10203	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Shahnawaz Sardar	
233	20ME4112	20P10220	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Ravi Kant Kumar	
234	20ME4113	20P10223	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Manish Kumar Choudhary	
235	20ME4114	20P10236	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Adarsh Shivshankar Tiwari	
236	20ME4116	20P10322	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Adarsh Madhukar	
237	20ME4117	20P10339	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Ganesh Suresh Kadam	

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238	20ME4118	20P10378	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rahul Dewangan	
239	20ME4119	20P10385	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rohit Kumar	
240	20ME4120	20P10393	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Aadil Ahmad Rather	
241	20ME4121	20P10423	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Abhishek Bhardwaj	
242	20ME4201	20P10049	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Vikash Kumar	
243	20ME4202	20P10057	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Sanam Karmakar	
244	20ME4203	20P10059	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Nitish Kumar	
245	20ME4204	20P10068	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Satya Subham Dash	
246	20ME4205	20P10079	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Somnath Patra	
247	20ME4206	20P10092	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Ashutosh Kumar	
248	20ME4207	20P10102	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Bikash Mohanty	
249	20ME4209	20P10182	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Sainath Jamalpuri	
250	20ME4210	20P10241	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Ravinder Nath	
251	20ME4211	20P10244	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Ankit Arunrao Shivankar	
252	20ME4212	20P10284	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Manish Kumar	
253	20ME4213	20P10302	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Shwetank Pushkar	
254	20ME4214	20P10315	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Meraj Haider	
255	20ME4215	20P10330	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Sarvesh Kumar Yadav	
256	20ME4217	20P10397	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Mrinal Sen Raj	
257	20ME4301	20P10041	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Ayushman Dutta	
258	20ME4302	20P10046	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Nawes Qamar	
259	20ME4303	20P10060	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Neel Srivastava	

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260	20ME4304	20P10113	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Mudhundi Ajay Kumar	
261	20ME4305	20P10152	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Nilanjan Mandal	
262	20ME4306	20P10154	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Md Ishteyaqe Alam	
263	20ME4307	20P10193	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Sai Ganesh Nerusu	
264	20ME4309	20P10252	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Tadiboina Naga Raju	
265	20ME4310	20P10253	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Subhadip Mondal	
266	20ME4312	20P10285	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Rahul Barnwal	
267	20ME4314	20P10328	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Rohanbhai Jesingbhai Dodiya	
268	20MM4101	20P10032	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Kunal Das	
269	20MM4102	20P10047	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Bishal Bidyut Buragohain	
270	20MM4103	20P10306	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Himangshu Saikia	
271	20MM4105	20P10396	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Shriya Pandey	
272	20MM4106	20P10441	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Akankshya Rout	
273	20MM4108	20P10444	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Anupam Sharma	
274	20MM4109	20P10447	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Rahul Dhibar	
275	20MM4110	20P10453	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Titindra Nath Paul	
276	20MM4111	20P10454	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Parthasarathi Maity	
277	20PH4101	20P10143	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Harshan Bhattacharjee	
278	20PH4102	20P10307	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Noorbasha Bhavani Sai	
279	20PH4103	20P10318	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Vikram Bharti	
280	20PH4105	20P10437	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Himanshu Shekhar	
281	20PH4106	20P10450	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Athul Raj. R S	
282	20BT4501	20P20055	Master of Science	in Life Sciences	(Department of Biotechnology)	Mayur Anil Umap	
283	20BT4502	20P20076	Master of Science	in Life Sciences	(Department of Biotechnology)	Sritama Sarkar	
284	20BT4503	20P20087	Master of Science	in Life Sciences	(Department of Biotechnology)	Anshuman Singh	
285	20BT4506	20P20131	Master of Science	in Life Sciences	(Department of Biotechnology)	Samprita Das	
286	20BT4507	20P20132	Master of Science	in Life Sciences	(Department of Biotechnology)	Kunal Das	
287	20BT4508	20P20246	Master of Science	in Life Sciences	(Department of Biotechnology)	J Kamal Atab	

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288	20BT4509	20P20263	Master of Science	in Life Sciences	(Department of Biotechnology)	Neha Maurya	
289	20BT4510	20P20281	Master of Science	in Life Sciences	(Department of Biotechnology)	Ilesa Bose	
290	20BT4511	20P20374	Master of Science	in Life Sciences	(Department of Biotechnology)	Anumita Ghanta	
291	20BT4512	20P20388	Master of Science	in Life Sciences	(Department of Biotechnology)	Sounak Sinha Babu	
292	20BT4513	20P20415	Master of Science	in Life Sciences	(Department of Biotechnology)	Kundali Yadav	
293	20CY4501	20P20062	Master of Science	in Chemistry		Dolly Singh	
294	20CY4502	20P20122	Master of Science	in Chemistry		Olympia Garai	
295	20CY4503	20P20139	Master of Science	in Chemistry		Raisa Rupal	
296	20CY4504	20P20144	Master of Science	in Chemistry		Mandira Ghosh	
297	20CY4506	20P20199	Master of Science	in Chemistry		Soumyanath Roy	
298	20CY4507	20P20201	Master of Science	in Chemistry		Koyel Bhattacharya	
299	20CY4508	20P20209	Master of Science	in Chemistry		Sanjukta Das	
300	20CY4509	20P20225	Master of Science	in Chemistry		Anartya Kundu	
301	20CY4510	20P20233	Master of Science	in Chemistry		Sanju Karmakar	
302	20CY4511	20P20240	Master of Science	in Chemistry		Pooja Kumari	
303	20CY4512	20P20243	Master of Science	in Chemistry		Rupa Sarma	
304	20CY4513	20P20264	Master of Science	in Chemistry		Subham Das	
305	20CY4514	20P20266	Master of Science	in Chemistry		Payel Nandi	
306	20CY4515	20P20283	Master of Science	in Chemistry		Dipannita Ganguly	
307	20CY4516	20P20292	Master of Science	in Chemistry		Dipanwita Rout	
308	20CY4517	20P20301	Master of Science	in Chemistry		Pulak Pradhan	
309	20CY4518	20P20312	Master of Science	in Chemistry		Prithish Banerjee	
310	20CY4519	20P20333	Master of Science	in Chemistry		Aman Kesharwani	
311	20CY4520	20P20350	Master of Science	in Chemistry		Deepak	
312	20CY4521	20P20377	Master of Science	in Chemistry		Priya Patra	
313	20CY4522	20P20379	Master of Science	in Chemistry		Soudip Pandit	
314	20CY4523	20P20409	Master of Science	in Chemistry		Abhishek Mahato	
315	20CY4524	20P20428	Master of Science	in Chemistry		Rituparna Saha	
316	20ES4503	20P20127	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Himanshu Das	
317	20ES4504	20P20150	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sritam Kumar Sahu	
318	20ES4505	20P20163	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Bimalesh Dutta	
319	20ES4506	20P20191	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Damudar Hansdah	
320	20ES4507	20P20204	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Prangyaparimita Sahoo	
321	20ES4508	20P20205	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Ashish Kumar Kalendri	
322	20ES4509	20P20234	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Chinmoyee Borgohain	
323	20ES4511	20P20276	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Abir Banerjee	

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324	20ES4512	20P20296	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sangeeta Koner	
325	20ES4513	20P20304	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Pratikshya Panda	
326	20ES4514	20P20310	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Suvendu Kumar Panda	
327	20ES4515	20P20313	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sanjay Kumar Nayak	
328	20ES4516	20P20321	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Saurav Gogoi	
329	20ES4517	20P20352	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Shashank Shekhar Mahapatra	
330	20ES4518	20P20363	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Aakanksha Sunil Borkar	
331	20ES4519	20P20404	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sagnik Das	
332	20ES4520	20P20426	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Manish Bundela	
333	20MA4501	20P20140	Master of Science	in Mathematics		Apurva Sharma	
334	20MA4503	20P20170	Master of Science	in Mathematics		Sayantan Kundu	
335	20MA4504	20P20206	Master of Science	in Mathematics		Itesh Kumar Singh	
336	20MA4505	20P20208	Master of Science	in Mathematics		Nitish Kumar	
337	20MA4506	20P20211	Master of Science	in Mathematics		Amitesh Ray	
338	20MA4507	20P20212	Master of Science	in Mathematics		Neelanjan Mondal	
339	20MA4508	20P20219	Master of Science	in Mathematics		Amit Patel	
340	20MA4509	20P20222	Master of Science	in Mathematics		Saikat Saha	
341	20MA4510	20P20237	Master of Science	in Mathematics		Soumik Chattopadhyay	
342	20MA4511	20P20239	Master of Science	in Mathematics		Pritam Ray	
343	20MA4512	20P20249	Master of Science	in Mathematics		Jahanvi Singh Rajpoot	
344	20MA4513	20P20255	Master of Science	in Mathematics		Pavan Suthar	
345	20MA4514	20P20259	Master of Science	in Mathematics		Muskan Choudhary	
346	20MA4515	20P20286	Master of Science	in Mathematics		Kajal Kumari	
347	20MA4516	20P20311	Master of Science	in Mathematics		Amrita Dutta	
348	20MA4517	20P20316	Master of Science	in Mathematics		Arpit Kumar	
349	20MA4518	20P20324	Master of Science	in Mathematics		Deepanshu Sharma	
350	20MA4519	20P20358	Master of Science	in Mathematics		Radheshyam Kumar	
351	20MA4520	20P20366	Master of Science	in Mathematics		Gopinath Sahoo	
352	20MA4521	20P20386	Master of Science	in Mathematics		Devendra Kumar	
353	20MA4522	20P20411	Master of Science	in Mathematics		Shashi Kumar Gupta	
354	20PH4501	20P20080	Master of Science	in Physics		Aniruddha Ray	
355	20PH4502	20P20084	Master of Science	in Physics		Saikat Mondal	
356	20PH4503	20P20105	Master of Science	in Physics		Aniket Nag	
357	20PH4507	20P20120	Master of Science	in Physics		Rohit Kumar Pandey	
358	20PH4508	20P20133	Master of Science	in Physics		Md Sohel Mondal	
359	20PH4509	20P20153	Master of Science	in Physics		Sougata Dandapathak	

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA

18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022
LIST OF POST GRADUATE DEGREE RECIPIENTS

Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
360	20PH4510	20P20186	Master of Science	in Physics		Biswajit Dash	
361	20PH4511	20P20195	Master of Science	in Physics		Shahid Raza	
362	20PH4513	20P20235	Master of Science	in Physics		Mainak Barman	
363	20PH4514	20P20268	Master of Science	in Physics		Ankita Das	
364	20PH4515	20P20272	Master of Science	in Physics		Pulakesh Barman	
365	20PH4516	20P20300	Master of Science	in Physics		Anik Biswas	
366	20PH4518	20P20344	Master of Science	in Physics		Manisha Paul	
367	20PH4520	20P20381	Master of Science	in Physics		Satarupa Mandal	
368	20PH4521	20P20424	Master of Science	in Physics		Anushka Yadav	
369	20PH4522	20P20433	Master of Science	in Physics		Debaprasad Nayak	
370	20MB4001	20P40001	Master of Business Administrations	(Specialization: Finance)		Debargha Sengupta	
371	20MB4002	20P40002	Master of Business Administrations	(Specialization: Finance)		Arya Shruti Parashar	
372	20MB4003	20P40003	Master of Business Administrations	(Specialization: Marketing)		Kumar Vivek	
373	20MB4004	20P40004	Master of Business Administrations	(Specialization: Finance)		Sourav Kumar Burman	
374	20MB4005	20P40005	Master of Business Administrations	(Specialization: Systems and Operations Management)		Harsh Maurya	
375	20MB4006	20P40006	Master of Business Administrations	(Specialization: Marketing)		Soumyadip Kundu	
376	20MB4007	20P40007	Master of Business Administrations	(Specialization: Finance)		Sanchita Surbhi	
377	20MB4008	20P40008	Master of Business Administrations	(Specialization: Marketing)		Shameek Shreya Saha	
378	20MB4010	20P40010	Master of Business Administrations	(Specialization: Finance)		Pritam Kumar Singh	
379	20MB4011	20P40011	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Payel Das	
380	20MB4012	20P40012	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Sandeep Kumar	
381	20MB4013	20P40013	Master of Business Administrations	(Specialization: Systems and Operations Management)		Saptarshi Mondal	
382	20MB4014	20P40014	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Ashmita Kumari	
383	20MB4015	20P40015	Master of Business Administrations	(Specialization: Marketing)		Alisha Banerjee	
384	20MB4019	20P40020	Master of Business Administrations	(Specialization: Marketing)		Rahul Kumar	
385	20MB4020	20P40021	Master of Business Administrations	(Specialization: Systems and Operations Management)		Sweta Kumari	
386	20MB4021	20P40022	Master of Business Administrations	(Specialization: Systems and Operations Management)		Divyank Kumar	
387	20MB4022	20P40023	Master of Business Administrations	(Specialization: Finance)		Ranu Priya	
388	20MB4023	20P40024	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Priyam Singh	
389	20MB4024	20P40025	Master of Business Administrations	(Specialization: Finance)		Haridwar Paswan	
390	20MB4025	20P40026	Master of Business Administrations	(Specialization: Systems and Operations Management)		Nidhi Kumari	
391	20MB4026	20P40391	Master of Business Administrations	(Specialization: Marketing)		Manohar Kumar Rai	
392	20MB4027	20P40407	Master of Business Administrations	(Specialization: Systems and Operations Management)		Sneha Dey	
393	20MB4028	20P40412	Master of Business Administrations	(Specialization: Finance)		Mainul Islam	
394	20MB4029	20P40414	Master of Business Administrations	(Specialization: Finance)		Akash Kumar Guha	

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA

18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022
LIST OF POST GRADUATE DEGREE RECIPIENTS

Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
395	20MB4031	20P40417	Master of Business Administrations	(Specialization: Finance)		Srijoni Guha	
396	20MB4032	20P40430	Master of Business Administrations	(Specialization: Finance)		Bhumika Bharti	
397	20MB4033	20P40431	Master of Business Administrations	(Specialization: Finance)		Chowdhury Wasim Akram	
398	20MB4035	20P40435	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Nandan Sharma	
399	20HS4001	20P20019	Master of Social Work			Srabasti Sen	
400	20HS4003	20P20028	Master of Social Work			Srinivasa Nammalwar K	

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

INDIA

18TH CONVOCATION

TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022

LIST OF INSTITUTE GOLD MEDAL RECIPIENTS OF POST GRADUATE PROGRAMME

Sl. No.	Regn. No.	Roll No.	Institute Gold Medal	to Name	In recognition of being	in	(Department of……….)	in the academic session ending in June 2022
1	20P10112	20BT4103	Institute Gold Medal	Shalini Das	In recognition of being First in Master of Technology	in Biotechnology	(Department of Biotechnology)	in the academic session ending in June 2022
2	20P10107	20CE4106	Institute Gold Medal	Bajrabahu Dhananjay Narayan Deo	In recognition of being First in Master of Technology	in Structural Engineering	(Department of Civil Engineering)	in the academic session ending in June 2022
3	20P10083	20CE4204	Institute Gold Medal	Abdul Waris	In recognition of being First in Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	in the academic session ending in June 2022
4	20P10452	20CH4112	Institute Gold Medal	Nikitha Lohia	In recognition of being First in Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	in the academic session ending in June 2022
5	20P10089	20CS4111	Institute Gold Medal	Debasish Kalita	In recognition of being First in Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	in the academic session ending in June 2022
6	20P10061	20EC4102	Institute Gold Medal	Samyat Sahu	In recognition of being First in Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication	in the academic session ending in June 2022
7	20P10125	20EC4205	Institute Gold Medal	Jeevan Tulashiram Thakare	In recognition of being First in Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication	in the academic session ending in June 2022
8	20P10340	20EE4115	Institute Gold Medal	Sayantan Chatterjee	In recognition of being First in Master of Technology	in Power Systems	(Department of Electrical Engineering)	in the academic session ending in June 2022
9	20P10071	20EE4204	Institute Gold Medal	Suman Karmakar	In recognition of being First in Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	in the academic session ending in June 2022
10	20P10282	20ES4112	Institute Gold Medal	Shardul Srivastava	In recognition of being First in Master of Technology	in Environmental Science and Technology		in the academic session ending in June 2022
11	20P10086	20MA4105	Institute Gold Medal	Sanju Kushwaha	In recognition of being First in Master of Technology	in Operations Research	(Department of Mathematics)	in the academic session ending in June 2022
12	20P10069	20ME4104	Institute Gold Medal	Gangineni Sandeep	In recognition of being First in Master of Technology	in Machine Design	(Department of Mechanical Engineering)	in the academic session ending in June 2022
13	20P10092	20ME4206	Institute Gold Medal	Ashutosh Kumar	In recognition of being First in Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	in the academic session ending in June 2022
14	20P10046	20ME4302	Institute Gold Medal	Nawes Qamar	In recognition of being First in Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	in the academic session ending in June 2022
15	20P10441	20MM4106	Institute Gold Medal	Akankshya Rout	In recognition of being First in Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials	in the academic session ending in June 2022
16	20P10307	20PH4102	Institute Gold Medal	Noorbasha Bhavani Sai	In recognition of being First in Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	in the academic session ending in June 2022
17	20P20263	20BT4509	Institute Gold Medal	Neha Maurya	In recognition of being First in Master of Science	in Life Sciences	(Department of Biotechnology)	in the academic session ending in June 2022
18	20P20233	20CY4510	Institute Gold Medal	Sanju Karmakar	In recognition of being First in Master of Science	in Chemistry		in the academic session ending in June 2022
19	20P20276	20ES4511	Institute Gold Medal	Abir Banerjee	In recognition of being First in Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	in the academic session ending in June 2022
20	20P20212	20MA4507	Institute Gold Medal	Neelanjan Mondal	In recognition of being First in Master of Science	in Mathematics		in the academic session ending in June 2022
21	20P20133	20PH4508	Institute Gold Medal	Md Sohel Mondal	In recognition of being First in Master of Science	in Physics		in the academic session ending in June 2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR								
INDIA								
18TH CONVOCATION								
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022								
LIST OF INSTITUTE GOLD MEDAL RECIPIENTS OF POST GRADUATE PROGRAMME								
Sl. No.	Regn. No.	Roll No.	Institute Gold Medal	to Name	In recognition of being	in	(Department of……….)	in the academic session ending in June 2022
22	20P40007	20MB4007	Institute Gold Medal	Sanchita Surbhi	In recognition of being First in Master of Business Administrations			in the academic session ending in June 2022
23	20P20019	20HS4001	Institute Gold Medal	Srabasti Sen	In recognition of being First in Master of Social Work			in the academic session ending in June 2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR					
INDIA					
18TH CONVOCATION					
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022					
Endowment Gold Medal Recipient					
PROF. M. S. SINHA MEMORIAL GOLD MEDAL (HIGHEST CGPA IN PHYSICS)					
Sl. NO.	Regn. No.	Roll No.	awards	To	
1	20P20133	20PH4508	Prof. M. S. Sinha Memorial Gold Medal (highest CGPA in Physics)	Md Sohel Mondal	for securing highest CGPA in Master of Science in Physics in the academic session ending in June 2022

Modified Curricula of **B Tech Minor Marketing Management**

	B Tech Minor Marketing Management					
Semester	**Name of the subject**		**L**	**T**	**P**	**Credits**
Sem V	Marketing Management		3	0	0	3
	Marketing Lab-I		0	0	2	1
Sem VI	Research Methodology		3	0	0	3
	Marketing Lab-I		0	0	2	1
Sem VII	Digital Marketing	Any Two	3	0	0	3
	Marketing Research		3	0	0	3
	Marketing Communication		3	0	0	3
	Consumer Behaviour		3	0	0	3
Sem VIII	Marketing Analytics	Any Two	3	0	0	3
	Sales and Distribution Management		3	0	0	3
	Service Marketing and Retail management		3	0	0	3
Total						20

GAUTAM BANDYOPADHYAY — 30.05.2022

Anupam De — 30/05/2022

Amlan Ghosh — 30/5/22

Subhadip Sarkar — 30.05.2022

Ujjwal K. Paul — 30/05/2022

N. Banerjee — 30/05/2022.

M Ray — 30/05/2022

A Dutta — 30/05/2022

Kaushik Mandal — K. Mandal 30/05/2022
HOD DMS

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
DEPARTMENT OF BIOTECHNOLOGY

June 22, 2022

Minutes of the Departmental Academic Committee (DAC)/ Departmental Postgraduate Academic Committee (DPAC)/Departmental Research Program Committee (DRPC) meeting held on June 22, 2022 at 3 p.m. in the Seminar Room of the Department of Biotechnology

The following members were present in the meeting:

1.	Dr. Debjani Dutta	Chairperson
2.	Prof. Apurba Dey	Member
3.	Prof. Sudit Sekhar Mukhopadhyay	Member
4.	Prof. Kaustav Aikat	Member
5.	Prof. Dalia Dasgupta Mandal	Member
6.	Dr. Monidipa Ghosh	Member
7.	Dr. Subhankar Roy Barman	Member
8.	Dr. Debojyoti De	Member
9.	Dr. Sudipta Mondal	Member
10.	Dr. Amita Barik	Member
11.	Dr. Oindrilla Mukherjee	U.G Coordinator
12.	Dr. Ashish Bhattacharjee	P.G (M.Sc) Coordinator
13.	Dr. Nibedita Mahata	P.G (M.Tech)Coordinator
14.	Dr. Sougata Saha	PhD Coordinator

The resolutions of the meeting are as follows:

1. The Load distribution for the ODD semester for the academic session 2022-2023 was discussed and is given as Annexure I.

2.In accordance with PG regulation 2017 (amended June 2021) clause no 11.3 (ii); the members have no objection in Mr. Sauma Suvra Majumdar (18BT1004) pursing his Master thesis work under the joint guidance of Dr. Debojyoti De, NIT Durgapur and Dr. Mohit Kumar Jolly, Assistant Professor, Centre for BioSystems Science and Engineering, Indian Institute of Science, Bangalore.

3. For academic year 2022-2023; BT3052 will be evaluated based on an original article presented by the students in presence of all the faculty members of the Department. Dr. Debjani Dutta will be in charge of the entire process.

4. A set of departmental norms has been consolidated based on DAC resolutions. The same would be circulated among the B.Tech/B.Tech-M.Tech (Dual Degree) M.Tech/M.Sc students and is given as Annexure II. All Departmental norms circulated are subjected to amendments as and when required.

5. The M.Sc. Life Science curriculum was modified to include the following electives from the existing M.Tech curriculum to the M.Sc elective basket. This was done to increase the choice of electives among the M.Sc students.

i) BT9031 Human Molecular Genetics

ii) BT9033 Signal Transduction

iii) BT9034 Molecular Cell Signalling

iv) BT9035 Food Biotechnology

v) BT9041 Advanced rDNA Technology and Cellular Biotechnology

6. The members appreciated the efforts of Mr. Pravesh Tamang, (Alumni-Batch 2015), currently working as a scientific assistant in the Science and Technology Wing at the Embassy of India in Berlin in reaching out to the Department to help in establishing collaboration with German institutions or universities. It was further resolved that he may be invited for the Research Day and requested to further brief the faculty members and students on the various modalities.

7. The Committee for outdoor unit reinstallation of Air Conditioner stands ratified and is composed of the following members: Dr. Subhankar Roy-Barman; Dr. Nibedita Mahata and Dr. Sudipta Mondal.

8. The members all resolved to inform their respective research scholars to be more cautious and return the Departmental keys to the Security Control Room upon completion of work.

The meeting ended with thanks to the Chair.

Debjani Dutta
22/6/22

Dr. Debjani Dutta

Chairperson, Department of Biotechnology

N. Mahata

<table>
<tr><td colspan="9">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO742</td><td>Mobile Communication</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Prerequisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On successful completion of this course, students should have the skills and knowledge to :

CO1: Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints.
CO2: Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.
CO3: Analyze and design receiver and transmitter diversity techniques. Evaluate the data rate performance.
CO4: Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel
CO5: Describe and differentiate five generations of wireless standard for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA); 4G (OFDM) and 5G technologies</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Module I. (L - 5)
Introduction to Wireless Personal Communication, Mobile radio systems.

Module II. (L - 10)
Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, Call blocking, Cell splitting and Directional antenna etc.

Module III. (L - 8)
Characterization of wireless radio channel, propagation path models. Fading and Shadowing.

Module IV. (L -12)
Receiver Techniques for fading Channel. Detection of Signal in Fading Channel, Receive Diversity, Transmit Diversity, Equalization, Fading mitigation.
Modulation schemes for wireless Communication (MSK, GMSK), OFDM, Multiple access techniques: Spread spectrum techniques, Cellular CDMA, NOMA

Module V. (L - 7)
Wireless Networks and Standards: GSM, CDMA Cellular standard, 3G, 4G</td></tr>
<tr><td>Text Books, and/or Reference material</td><td colspan="7">Text Books:

[1] Andrea Goldsmith, “Wireless Communication”, Cambridge University Press
[2] Aditya K Jagannathan, “Principles of Modern Wireless Communication Systems Theory and Practice”, McGraw-Hill India.
[3] David TSE and Pramod Viswanathan, “Fundamentals of Wireless Communication”,</td></tr>
</table>

	Cambridge University Press **Reference Books:** [1] Theodore Rappaport, "*Wireless Communications: Principles and Practice*", Pearson, 2nd Edition [2] Andreas. F. Molisch, "*Wireless Communication*", John Wiley and Sons [3] Mark and Zhuang, "*Wireless Communication and Networking*", PHI

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Program Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	1	1	-	-	-	-	-	-	-	3	1	3
CO#2	3	3	3	1	1	-	-	-	-	-	-	-	3	3	2
CO#3	3	3	3	1	1	-	-	-	-	-	-	-	3	2	3
CO#4	3	3	3	2	1	-	-	-	-	-	-	-	3	1	3
CO#5	3	3	3	2	2	-	-	-	-	1	-	-	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO744</td><td>Computational Biology and its Applications</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites:
Introduction to Computing, Linear Algebra, Fundamentals of Probability and Statistics, Basics of Biology</td><td colspan="5">Course Assessment methods (Continuous (CT) and End assessment (EA))</td></tr>
<tr><td>Course Out-comes</td><td colspan="7">• CO1: To develop the problem solving skill using the concept of algorithms
• CO2: To understand different computational algorithms including few clustering and classification techniques and genetic algorithm.
• CO3: To aware the basic principles and concept of Biology and identify the potential application areas.
• CO4: To correlate the computational algorithms and the applicable biological domain.
• CO5: To develop new computer modelling for different types of biologicaldata</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1) Algorithms in Computing: Algorithms, Pseudocode, Time & Space Complexity, Dynamic Programming. (4)
2) Pattern Matching and Optimization: Hashing, Pattern Finding using Clustering, Genetic Algorithms, Evolutionary Computation Techniques, Case Study on GA basedfeature selection on microarray gene expression (8)
3) Hidden Markov Model: Markov process and Models, HMM applications(6)
4) Support Vector Machine: Introduction, Margin, Hyperplane, Classification. Bayes Theorem, Bayes Classifier. Case Study on Disease Classification(6)
5) Artificial Neural Network: Perceptron, Hidden Layers, Activation Functions, FeedForward Neural Network and Back Propagation, Case Study on Biological Image Classification(6)
6) Basics of Biology: Central Dogma of Molecular Biology, Molecular Visualization Software's, Protein Sequence and Structure Analysis, Protein Structure Modelling, Protein-protein Docking, Genomics. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">References:
1. An Introduction to Bioinformatics Algorithms, Neil C. Jones, Pavel Pevzner,MIT Press.
2. Bioinformatics: the Machine Learning Approach, Pierre Baldi, Soren Brunak MIT Press.
3. Genetic Algorithms in Search, Optimization and Machine Learning, David E. Goldberg.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	3	1	3	2	1	-	-	1	2
CO2	3	3	3	3	2	3	2	1	2	-	2	3
CO3	2	2	3	2	2	1	1	1	-	-	2	2
CO4	2	3	3	3	2	3	2	1	2	-	2	2
CO5	2	2	3	2	3	3	3	1	3	-	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Department of Chemical Engineering

Date: 28.06.2022

Minutes of DAC/DPAC meeting held on 28th June 2022 (Tuesday) from 10.30 pm onwards at the Departmental Meeting Room.

The following members were present during the meeting:

1. Dr. Parimal Pal, Professor (HAG)
2. Dr. Kartik Chandra Ghanta, Professor
3. Dr. Tamal Mandal, Professor
4. Dr. Anup Kumar Sadhukhan, Professor
5. Dr. Gopinath Halder, Professor
6. Dr. Susmita Dutta, Professor — S. Dutta 30/6/22
7. Dr. Jaya Sikder, Associate Professor (Chairperson)
8. Dr. Sandip Kumar Lahiri, Associate Professor
9. Dr. Mrinal Kanti Mandal, Associate Professor
10. Dr. Swapan Paruya, Associate Professor
11. Dr. Bimal Das, Assistant Professor
12. Dr. Abhiram Hens, Assistant Professor
13. Dr. Bikash Kumar Mondal, Assistant Professor
14. Dr. Rajib Ghosh Chaudhuri, Assistant Professor
15. Dr. Ananta Sarkar, DST-Inspire Faculty — Ananta Sarkar 29.06/22

The resolutions taken in the meeting are as follows:

Item # 2: To consider the responsibility distribution of unattended subjects in UG and Dual Degree curriculum in compliance with MOM dated 10.06.2022.

The subject's responsibility, CHE 613: Combustion Engineering, was taken by Prof. A. K. Sadhukhan. Prof. Gopinath Halder will provide all his modules' inputs to Prof. Sadhukhan as required.

Following unattended subjects were removed from the Dual Degree Program:

CH9017	Process Intensification and Green Technology
CH9019	Bioprocess and Bioreactor Engineering
CH9022	Combustion Engineering
CH9024	Project Engineering and Management
CH9025	Hazard Analysis and Risk Management in Chemical Industry
CH9029	Catalysis in Chemical Industry

Item # 4: To consider the future of the Dual Degree program in Chemical Engineering and the proposal for separate Dual Degree regulations.

Based on the several communications of dual degree students (pass out batches: 2021-22, 2022-23, 2023-24, **Annexure-III**), the Department analyses the feasibility of continuing the Dual Degree Program in the long run.
It is cumbersome to apply for NBA for seven numbers of the sanctioned seat and 3-5 practically admitted students considering it a separate program that mandates accreditation. The success rate

will be difficult to justify in the context of the present placement scenario of 1st passed-out batches in the 2021-22 academic year.

Hence the Department strongly recommended closing down the dual degree program from 2023-24 academic year onwards.

The sanctioned seven-seat may be merged with the BTech program; hence, the total BTech sanctioned strength will be 75 (present) + 7 = 82 seats.

Item # 5: To consider the shortlisting of candidates under sponsored MTech program & finalization of advertisement for the self-sponsored MTech program

The applicant, Sri Subhajit Patra, was recommended for shortlisting upon fulfilling the eligibility criteria as per the advertisement (**Annexure-IV**).

The draft advertisement for the self-sponsored MTech program was accepted as received from the office of Dean (AC) and finalized.

The Chairperson ended the meeting by giving thanks to the members for their kind presence and valuable opinion.

for Bimal Das.

Convener
DAC/DPAC/DRPC

Sikdar 01/07/22

Chairperson
DAC/DPAC/DRPC

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
MAHATMA GANDHI AVENUE, DURGAPUR - 713209, WEST BENGAL, INDIA

INTER OFFICE MEMO

NITD/ACAD/ 2022-23 Date: 27.06.2022

From:
Dean (Academic Courses)
NIT Durgapur

To:
The ~~HOD~~, CH
NIT Durgapur

Sub: Short listing of candidates - admission to M. Tech sponsored program 2022-2023 without scholarship.

1. Enclosed please find an application from Sri Subhajit Patra regarding admission to M. Tech sponsored program 2022-2023 without scholarship.

2. You are kindly requested to go through the application to look into the matter of suitability of the candidate with reference to the advertisement as enclosed.

3. You are kindly requested to reply on the matter of suitability for short listing of the candidate to the Dean (Academic Courses) by 28.06.2022 Tuesday.

Your kind cooperation in this respected is highly solicited.

27/6/2022
Dean (Academic Courses)

To The PG coordinator for N/A
27.06.22

28.6.22

To The Dean (Academic Courses)
Sir, The applicant, Sri Subhajit Patra is suitable for short listing for the said program as per criteria. ~~The~~ eligibility criteria are fulfilled.
28.06.22

Head of Department
Department of Chemical Engineering
National Institute of Technology Durgapur
Durgapur-713209, WB, India

28/6/22

Date: July 19, 2022

To,
The Dean of Academic Courses,
National Institute of Technology Durgapur

Dear Sir,
As per the ECE DAC meeting held on July 19, 2022, the following points are resolved:

1. To incorporate the following Open Electives (As given in Table I below) into the existing UG curriculum of the ECE department.

Table: I

Course	Specialization	Type of Elective	L-T-P	Paper Code	Paper Name
B.TECH	N/A	Open Elective	3-0-0	ECO442	Electronic Design
			3-0-0	ECO742	Mobile Communication
			3-0-0	ECO743	Internet of Things
			3-0-0	ECO843	EMI/EMC
			3-0-0	ECO853	Electronic System Design

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO742</td><td>Mobile Communication</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On successful completion of this course, students should have the skills and knowledge to :

CO1: Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints.
CO2: Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.
CO3: Analyze and design receiver and transmitter diversity techniques. Evaluate the data rate performance.
CO4: Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel
CO5: Describe and differentiate five generations of wireless standard for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA); 4G (OFDM) and 5G technologies</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Module I. (L - 5)
Introduction to Wireless Personal Communication, Mobile radio systems.

Module II. (L - 10)
Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, Call blocking, Cell</td></tr>
</table>

	splitting and Directional antenna etc. **Module III. (L - 8)** Characterization of wireless radio channel, propagation path models. Fading and Shadowing. **Module IV. (L -12)** Receiver Techniques for fading Channel. Detection of Signal in Fading Channel, Receive Diversity, Transmit Diversity, Equalization, Fading mitigation. Modulation schemes for wireless Communication (MSK, GMSK), OFDM, Multiple access techniques: Spread spectrum techniques, Cellular CDMA, NOMA **Module V. (L - 7)** Wireless Networks and Standards: GSM, CDMA Cellular standard, 3G, 4G
Text Books, and/or Reference material	**Text Books:** [1] Andrea Goldsmith, "*Wireless Communication*", Cambridge University Press [2] Aditya K Jagannathan, "*Principles of Modern Wireless Communication Systems Theory and Practice"*, McGraw-Hill India. [3] David TSE and Pramod Viswanathan, "*Fundamentals of Wireless Communication*", Cambridge University Press **Reference Books:** [1] Theodore Rappaport, "*Wireless Communications: Principles and Practice*", Pearson, 2nd Edition [2] Andreas. F. Molisch, "*Wireless Communication*", John Wiley and Sons [3] Mark and Zhuang, "*Wireless Communication and Networking*", PHI

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Program Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	1	1	-	-	-	-	-	-	-	3	1	3
CO#2	3	3	3	1	1	-	-	-	-	-	-	-	3	3	2
CO#3	3	3	3	1	1	-	-	-	-	-	-	-	3	2	3
CO#4	3	3	3	2	1	-	-	-	-	-	-	-	3	1	3
CO#5	3	3	3	2	2	-	-	-	-	1	-	-	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 43</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO743</td><td>Internet of Things</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods:
Continuous (CT), Mid-Term (MT), End Assessment (EA)</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Explain the term IoT and understand the main components of IoT systems.
CO2: Recognize, interpret and apply a variety of enabling technologies, connectivity technologies and communication protocols that occur in IoT systems.
CO3: Design and analysis of a complete working IoT system involving prototyping, programming and data analytics</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction to IoT: Introduction and definition of IoT;
-Basics of networking: Network types; Network topologies; OSI model; Adressing TCP/IP;
-Predecessors of IoT: WSN; M2M; Cyber Physical Systems (5L)
2. IoT enabling technologies: Cloud computing; Big data analytics; Embedded systems;
-IoT levels: level 1 to level 6
-Introduction to sensors; actuators; microcontrollers, and their interfacing: Sensors-characteristics, types; Sensor interfacing-interfacing gas sensors with nodeMCU/ Arduino, interfacing pH sensor, interfacing pulse sensor.
-Actuators: types, functions
-Microcontrollers and overview (8L)
3. IoT communication technologies:
-Constrained nodes and networks: types; lossy and low power networks
-Protocols for messaging and transport: Messaging protocols- MQTT; CoAp; XMPP; DDS
-Protocols for addressing and identification: IPV4; IPV6; Uniform Resource Identifier (URI); 6LoWPAN; Discovery protocols like universal plug and play; multicast DNS. (6L)
4. IoT connectivity technologies: IEEE 802.15.4; Zigbee; RFID; NFC; Sigfox; LoRa; NB-IoT; WiFi; Bluetooth (2L)
5. Cloud for IoT: challenges; selection of cloud service provider; introduction to Fog computing- working principle; edge and Fog computing; security aspects. (2L)
6. Data analytics: Data analysis; Machine learning: supervised and unsupervised; Types of ML models: classification; regression; clustering; Model building process; modeling algorithm; model performance; Big data platform. (5L)
7. IoT case studies and future trends: Agricultural IoT; Vehicular IoT; Healthcare IoT; Evolution of new IoT paradigms- IoBT; IoV; IoNT; IoD; IoSpace; NFV; SDN; 5G as IoT enabler. (6L)
8. IoT hands on:-Home automation: smart lighting;Air pollution monitoring;Health care: elderly fall detection; Prevention of drowsiness of drivers by IoT based smart drivers assistance systems. (9L)</td></tr>
</table>

Text Books, and/or reference material	**Text Books**: 1. Shriram K Vasudevan; Abhishek S Nagarajan; RMD Sundaram, *Internet of Things*, 2nd Edition, Wiley, New Delhi, 2020. 2. S. Mishra, A. Mukherjee, A. Roy, *Introduction to IoT*, 1st Ed., Cambridge University, UK, 2021. **Reference Books**: 3. A. Bahga, V. Madisetti, *Internet of Things: A Hands-on approach*, 1st Ed., Universities Press (India) Pvt. Ltd., Hyderabad, 2014. 4. K. N. Raja Rao (editor), *Internet of Things: Concepts and Applications*, 1st ed., Wiley India, 2021.

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO **CO**	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#2	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3
CO#3	3	2	3	3	3	2	2	1	-	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total number of contact hours = 46</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO843</td><td>EMI/EMC</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="2">1. Signals and Systems (ECC303)
2. Analog Communication (ECC401)
3. Digital Communication (ECC501)
4. Electromagnetic Theory and Transmission Lines (ECC403)
5. Microwave Engineering (ECC502)</td><td colspan="6">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO#1 Ability to understand the basic knowledge of the sources of electromagnetic interference and electronic equipment classes based on standards
CO#2 Ability to analyze, explain and resolve technical problems related to electromagnetic interference
CO#3 Develop an ability to devise methodologies to mitigate electromagnetic interference and make the electronic system compatible</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Introduction to EMI - Definitions, Different Sources of EMI (Electro-magnetic Interference), Electro-static discharge (ESD), Electro-magnetic pulse (EMP), Lightning, and Mechanism of transferring Electro-magnetic Energy: Radiated emission, radiated susceptibility, conducted emission, and conducted susceptibility, Differential & common mode currents. Concepts of EMC, EMC units. [L-8]

Transmission Line Theory: transmission by guided media, idea of propagation characteristics and computation of VSR, reflection coefficient, scattering parameters. Transients of transmission line, Time-domain Reflectrometry (TDR) basics for determining the properties of a transmission line. Planar Transmission lines Pattern of EM field distribution in a Micro-strip Line, Derivation of Effective Dielectric Constant, Characteristic impedance & Attenuation, Different Micro-strip line design examples, coupled transmission lines, concept of signal integrity [L-8]

Impedance Matching & Tuning : Purpose of Impedance matching, Factors important in the selection of a particular matching network, Different types of Impedance matching, Single stub matching, double stub matching, The quarter-wave transformer, Quarter-wave transformer bandwidth calculation, theory of small reflection, Single-section Transformer, Multi-section Transformer [L-8]

Electromagnetic Sensors and Measurement: Antenna types and their use as sensors, effective height, antenna factor, broadband and multiband electromagnetic sensors, sub wavelength electromagnetic sensors, Power losses in cable, calculation of signal source output for a mismatched load, Measuring & Test systems, Test facilities, measurements of radiated emission in open test range & in Anechoic chamber, Conducted emission testing by Line Impedance Stabilization network (LISN). [L-8]

EMC requirements for electronic systems: World regulatory bodies- FCC, CISPR etc.</td></tr>
</table>

	Class-A devices, class-B devices, Regulations of the bodies on EMC issues. **[L-6]** Mitigation Techniques Grounding: Fundamental grounding concepts, Floating ground, Single-point & Multi-point ground, advantages & disadvantages of different grounding processes. Shielding, Cross-talks & Coupling, Measurement set for measuring Cross-talk. Filtering & decoupling. **[L-6]** Electromagnetic pulse and application in warfare, electromagnetic discharge **[L-2]**
Text Books, and/or Reference material	**Text Books:** [1] Clayton R.Paul , *Introduction to Electromagnetic compatibility*- John Wiley & Sons [2] Albert A. Smith Jr., *Radio Frequency Principles and Applications: The Generation, Propagation, and Reception of Signals and Noise*, Wiley-IEEE Press, New York 1998 **Reference Books:** [1] Frederick M Tesche, Michel V.Ianoz, Torbjorn Karlsson, *EMC Analysis Methods & Computational Models*-; John Willey & Sons, Inc [2] Paul G. Huray, *The Foundations of Signal Integrity*, John Wiley & Sons, Inc., 2010

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	2	3	2	2	2	2	1	2	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO853</td><td colspan="2">Electronic System Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="3">Basic Electronics (ECC01)
Engineering Mechanics (XEC01)</td><td colspan="6">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">After the completion of the course the student will be able to
• CO 1: Understand concept of electronic systems
• CO 2: Understand basic building blocks of electronic systems
• CO 3: Apply quantitative analysis techniques to electronic systems
• CO 4: Learn design techniques of electronic measurement systems
• CO 5: Investigate application specific measurement systems</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Module I: Introduction to electronic systems [L-1]

Module II: Static and dynamic characteristics [L-6]
Static characteristics of elements, Dynamic characteristics of elements, Quasi-static characteristics of elements, Static characteristics of systems, Dynamic characteristics of systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth.

Module III: Electro-Multiphysics Actuation Systems [L-7]
Electro-magnetic actuators, Electro-mechanical actuators, Electro-thermal actuators, Electro-chemical actuators, Electro-optic actuators, Additional Multiphysics Mechanisms, Electro-Multiphysics drivers.

Module IV: Microcontrollers, Microcomputers and signal processing unit [L-5]
8051, Arduino, Raspberry pi

Module V: Sensors [L-8]
Temperature sensors, Force sensors, Pressure sensors, Vibration sensors, Flow sensors, Motion Sensors, Magnetic flux sensors, Chemical sensors.

Module VI: Signal Conditioning circuits [L-6]
Bridge circuits, Amplifiers, Filters, Oscillators, ADC

Module VII: Data presentation unit [L-3]
Several data presentation devices

Module VIII: Electronic controllers [L-4]
Open loop systems, Closed loop systems, PID controllers

Module IX: Case studies [L-2]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Text Books:
1. J. Bentley, Principles of measurement systems. Pearson Education India; 3rd edition, 2002
2. W. Bolton, Mechatronics, Fourth Edition, Pearson, 2010
3. Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems: 7th Edition McGraw-Hill; Seventh edition, 2019
4. David A. Bell, Electronic Instrumentation and Measurements, Oxford University Press India; Third edition, 2013</td></tr>
</table>

	Reference books: 1. Research Articles

COURSE ARTICULATION MATRIX

Mapping Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO):

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	-	-	-	-	2	-	-	-	-	-	-	3	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO#3	1	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO#4	2	1	2	-	-	2	-	-	-	-	-	-	3	2	-
CO#5	1	1	1	3	-	2	-	-	-	-	-	-	2	1	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

2. Some Electives are added or modified w.r.t the existing M.Tech- Microelectronics and VLSI curriculum, as given in Table II.
(Please note that the Proposed/ Modified Electives for the PG VLSI are already available with the PG Next Generation Communication and Networks)

Table: II

Existing List of Electives			Revised List of Electives			Added/ Modified
L-T-S	**SUBJECT CODE**	**SUBJECT**	**L-T-S**	**SUBJECT CODE**	**SUBJECT**	
3-1-0	EC9031	Digital Signal Processing & its applications	3-0-2	EC9001	Digital Signal Processing using MATLAB*	Modified
3-1-0	EC9033	Statistical Signal Processing	3-1-0	EC9002	Statistical Signal Processing	Modified
3-1-0	EC9034	Image Processing	3-0-2	EC9003	Applications of Image Processing using Python*	Modified
			3-1-0	EC9004	Automated Speech Signal Processing	Added
			3-1-0	EC9005	Probability & Random Process	Added
3-1-0	EC9030	Error Control Coding	3-1-0	EC9006	Error Correction Coding	Modified
3-1-0	EC9032	Detection & Estimation Theory	3-1-0	EC9007	Detection & Estimation Theory	Modified
3-1-0	EC9037	Optical Communication	3-1-0	EC9008	Optical Communication & Networks	Modified
			3-1-0	EC9009	Cooperative Communication Networks	Added
			3-1-0	EC9010	Network Information Theory and Coding	Added
			3-1-0	EC9011	<u>Digital Microwave Communication</u>	Added
			3-1-0	EC9012	Microwave Photonics	Added
			3-1-0	EC9013	Radiating Systems for Next Gen Communication	Added
3-1-0	EC9036	Microwave & Millimeter Wave Circuits	3-1-0	EC9014	Microwave and Millimeter-wave Measurements	Modified
			3-1-0	EC9015	Microwave Solid state Devices	Added
3-1-0	EC9039	Satellite Communication	3-1-0	EC9016	Digital Satellite and Navigational Systems	Modified
			3-1-0	EC9017	Bimolecular Communication	Added
3-1-0	EC9035	Queuing Theory for Telecommunication	3-1-0	EC9018	Queuing Theory for Telecommunication	Modified
			3-1-0	EC9019	Quantum Communication and Computing	Added
			3-0-0	EC9020	Cloud Computing	Added
3-1-0	EC9040	Artificial Intelligence & Soft Computing	3-1-0	EC9021	Machine Learning and Deep Learning using Python	Modified

			3-1-0	EC9022	Big Data Computing	Added
3-1-0	EC9046	Internet of Things (IoT)	3-1-0	EC9023	Internet of Things (IoT)	Modified
			3-1-0	EC9024	Virtual Reality and Augmented Reality	Added
			3-1-0	EC9025	Network Function Virtualization & Software Defined Networks	Added
			3-1-0	EC9026	Game Theory for Telecom Management	Added
3-1-0	EC9053	Physical System Analysis and Modeling	3-1-0	EC9027	Multiphysics Analysis and Modeling using COMSOL/ANSYS	Modified
3-1-0	EC9049	Mixed Signal IC Design	3-1-0	EC9028	Mixed Signal IC Design	Modified
			3-1-0	EC9029	Architectural Design of ICs	Added
3-1-0	EC9041	RF IC DESIGN	3-1-0	EC9030	RF IC Design	Modified
3-1-0	EC9042	SoC Design	3-1-0	EC9031	SoC Design	Modified
3-0-2	EC9043	*FPGA based design	3-0-2	EC9032	FPGA based design*	Modified
3-1-0	EC9045	Embedded Systems	3-1-0	EC9033	Embedded Systems	Modified
3-1-0	EC9044	MEMS & Microsystem Technology	3-1-0	EC9034	MEMS & Microsystems Technology	Modified
3-1-0	EC9047	Nanoelectronics	3-1-0	EC9035	Nanoelectronics	Modified
3-1-0	EC9048	ASIC Design using Verilog/VHDL	3-0-2	EC9036	ASIC Design using Verilog/VHDL*	Modified
3-1-0	EC9050	Low Power Circuits and Systems	3-1-0	EC9037	Low Power Circuits and Systems	Modified
3-1-0	EC9051	Testing and Verification of VLSI Circuits	3-1-0	EC9038	Testing and Verification of VLSI Circuits	Modified
3-1-0	EC9052	Computer Architecture	3-1-0	EC9039	Advanced Computer Architecture	Modified
3-1-0		DSP Architectures in VLSI	3-1-0	EC9040	DSP Architectures in VLSI	Modified
3-1-0	EC9057	Power Management IC Design	3-1-0	EC9041	Power Management IC Design	Modified
3-1-0	EC9054	Cyber Physical Electronic System Design	3-1-0	EC9042	Cyber Physical Electronic System Design	Modified
3-1-0	EC9058	Smart Materials based Electronic Devices	3-1-0	EC9043	Smart Material based Devices	Modified

***The Lecture, Tutorial and Sessional distribution of EC9001, EC9003, EC9032, and EC9036 are 3, 0 and 2, respectively.**

Note: Antenna Analysis & Synthesis (EC9038**) and Electronic Measurements and System Design (**EC9055**) subjects have been removed from the revised M.Tech- Microelectronics and VLSI curriculum.**

3. Revised MINOR in Electronics is Proposed

Department	Minor in	Credits	Curriculum for Minor		Who are not eligible	Students required to float the program	
			Theory	Lab/Sessional		Minimum	Maximum
Electronics and Communication Engineering	Electronics	22	2 core + 4 elective	1 lab	B.Tech in ECE / EE / CSE	10	30

Curriculum Structure for Minor in ELECTRONICS

Sl. No	Subject Code	Subject	L	T	S	C	H
Semester - 4							
Sl. No	**Subject Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECC402	Digital Circuits and Systems (CORE)	3	1	0	4	4
2	ECO441/ECO841	Elective I	3	0	0	3	3
		TOTAL	**6**	**1**	**0**	**7**	**7**
Semester -5							
Sl. No	**Subject Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECC302	Electronic Devices and Circuits - I (CORE)	3	1	0	4	4
		TOTAL	**3**	**1**	**0**	**4**	**4**
Semester - 6							
Sl. No	**Subject Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECC403/ECE616	Elective II	3	0	0	3	3
2	ECO843/ECO853 (**Both are proposed**)	Elective III	3	0	0	3	3
		TOTAL	**6**	**0**	**0**	**6**	**6**
Semester - 7							
Sl. No	**Subject Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECO742/ECO743 (**Both are proposed**)	Elective IV	3	0	0	3	3
2	NOT GIVEN	Micro-credit Course (LAB)	0	0	3	2	3
		TOTAL	**3**	**0**	**3**	**5**	**6**
		TOTAL	**18**	**2**	**3**	**22**	**23**

List of electives:

Elective – I		Elective - II		Elective - III		Elective - IV	
Subject Code	Subject Name	Subject Code	Subject Name	Subject Code	Subject Name	Subject Code	Subject Name
ECO441	Communication Engineering	ECC403	Electromagnetic Theory and Transmission Lines	ECO843 (**Proposed**)	EMI/EMC	ECO742 (**Proposed**)	Mobile Communication
ECO841	Signal Processing	ECE616	VLSI Technology	ECO853 (**Proposed**)	Electronic System Design	ECO743 (**Proposed**)	Internet of Things

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Academic Section

Date: 31.08.2022

Minutes of the meeting of UGAC and PGAC held jointly at the meeting room of the Academic Section on 31.08.2022 (Wednesday) at 03.00 pm.

The Chairman welcomed the members to the meeting. The agenda items were placed for discussion.

Item # 1 **Confirmation of the minutes of UGAC and PGAC held on 29.07.2022.**

The minutes of the UGAC and PGAC meeting held on 29.07.2022 were confirmed.

The matter regarding project evaluation for the final year students of M. Tech program undergoing one year internship in the industry will be taken up after receiving the observations of the respective DPAC of all the departments.

Item # 2 **To consider the publication of**

a. **Corrigendum result – Even Semester 2021-2022.**
b. **Supplementary / Back-log results, Even Semester 2021-22.**

The corrigendum results, Even Semester 2021-22 and Supplementary / Back-log results, Even Semester 2021-22 are recommended for approval and subsequent publication.

A faculty representative from the DAC of Student Activity Centre (SAC) may be inducted in the UGAC as a member, on approval of the Senate.

Item # 3 **To consider the appeal on cancellation of admission –**

Sl No.	Reg. No.	Roll No.	Name	Programme
1	22P10359	22EE4110	ROOPSI VERMA	M.TECH
2	22P40010	22MB4010	MIDDE CHANDANA	MBA
3	21U10033	21C80004	MANIK SULTANIA	B.TECH
4	22P10350	22BT4112	ABHISHEK KUMAR	M.TECH
5	21U10733	21C80074	SOUNAK MUNSHI	B.TECH
6	22P20330	22BT4513	ROMI RISHIT GEORGE	MSC

The matter of withdrawal by the respective students is accepted. The Institute fee and Hostel fee paid by the candidates/students will not be refunded. Institute caution money, if any, may be refunded to the bank account of the individual students after the current financial year.

No refund will be admissible to the candidates, who do not take admission to the Institute after final allotment of seats through centralized counselling such as CCMT, CCMN, CSAB, JoSAA, etc. Amount paid by such candidates during the counselling process and admission process will not be refunded.

Item # 4 **To consider re-admission of Md. Faisal (Roll No. 19ME8158, Reg. No. 19U10731) to 5th Semester 2022-2023 and Souvik Kumar Saha (Roll No 21F80063, Regn. No.21U10626) to 2nd Semester 2022-2023.**

The matter is recommended for approval.

Dean (Academic Courses)
National Institute of Technology
Durgapur-713209 India

Item # 5 **To consider the academic matter related to Debadrita Banerjee (Reg. No. 21U10750) and Dande Harshini (Roll No. 20BT8005, Reg. No. 20U10176 – B. Tech in Biotechnology) Ragiri Shireesha (Roll No. 20BT1007, Reg. No. 20U10756 – Dual Degree in Biotechnology) and Sobhag Bairwa (Roll No. 21D80083, Reg. No. 21U10824 – B.Tech in Computer Science and Engineering) .**

The matter was discussed in detail and it was resolved that

- Since Debadrita Banerjee (Reg. No. 21U10750) could not appear in all the examinations of her study in second semester, 2021-22, (due to medical reasons) she is recommended to take re-admission in 2nd Semester 2022-2023 in accordance with the provisions of the regulations of UG program.
- As per the records of even semester 2020-21, Dande Harshini (Roll No. 20BT8005, Reg. No. 20U10176 – B. Tech in Biotechnology) Ragiri Shireesha (Roll No. 20BT1007, Reg. No. 20U10756 – Dual Degree in Biotechnology) were declared "Failed" in the second semester of their study. Therefore, they are recommended to take re-admission in 2nd Semester 2022-2023 in accordance with the provisions of the regulations of UG program.
- Sobhag Bairwa (Roll No. 21D80083, Reg. No. 21U10824 – B.Tech in Computer Science and Engineering) is recommended to take re-admission in 1st Semester 2022-2023 in accordance with the provisions of the regulations of UG program.

Item # 6 **To recommend the matter related to change of branch for admission year 2021-2022 of B. Tech / Dual Degree / Integrated M. Sc Program.**

The matter is recommended for post facto approval as the branch changes are already implemented upon receipt of approval on circulation from the UGAC members.

Item # 7 **To consider the matter on appearing the 2nd semester supplementary examination 2021-2022 under medical condition of - Vidhi Srivastava (Roll No. 21F80043 – MAC02, ESC01, CYC01, PHC01, XXC01) Samarth Kumar Wadhawan (Roll No. 21J80080 – MAC02, ESC01, CYC01, PHC01, XXC01), Rajiv Sarkar (Roll No. 19ME8025 – MEE 613, MEE 625, MEE 631), Agnivo Ghosh (Roll no. 21H80011 - CYC 01, PHC 01, ESC 01, MAC 02, XXC 01), Ch Sanghamitra (Roll no. 20CS 8094 – CHO 441, CSC 401, CSC 402, CSC 403, CSC 404, CSC 405)**

The matter will be dealt in accordance with the existing norms / provisions of the regulations of UG program.

Item # 8 **To consider the matter of minor modifications in UG syllabus.**

The matter is finalized after incorporating minor modifications in UG curriculum and syllabus (See Annexure I).
It has been observed that some overlaps exist among a few subjects (open elective subjects offered by different departments, core/departmental electives offered by one department to open elective subjects offered by the other departments or vice-versa). To resolve this matter, following initiatives are to be taken by the departments at the earliest

(a) Grouping of similar subjects within/across the programs and floating in the same semester
(b) A table (see the example below) showing mapping between a subject to their pre-requisite subjects and subjects having similar content as follows

Dean (Academic Courses)
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Durgapur-713209 India

Table 1: Mapping table between pre-requisite and similar subjects

Subject Code	Codes of pre-requisite subject (s)	Codes of similar subject (s)
ECO740: Biomedical Instrumentation	NIL	EEO741: Biomedical Instrumentation EEO841: Biomedical Instrumentation
ECO542: Artificial Intelligence and Soft Computing	NIL	CSO843: Soft Computing Techniques EEO850: Soft Computing Techniques

Item # 9 **To consider the changes in Academic Calendar for first year UG students.**

The revised Academic Calendar incorporating the academic activities of first year UG students is recommended for approval of the Senate. (See Annexure II)

Item # 10 **To consider the modalities to be followed for content delivery and evaluation of 8th Semester UG students.**

Resolved for approval of the Senate that

- Mode of content delivery (for the theory and sessional subjects) will be online for all students in the 8th semester. However, end-term examination will be conducted offline in the institute.
- Evaluation of the internship report as a project report for the students opting to go for full semester industry internship will also be done in the offline mode along with the students staying on campus of the institute.

Item # 11 **To consider the matter related to upgrade the seat matrix of M. Tech (Microelectronics and VLSI Program) of ECE Department (intake from 20 to 40).**

The matter was discussed in detail. It has been observed that some of the MTECH programs of NIT Durgapur such as MTECH in Mirco-electronics and VLSI, MTECH in Structural Engineering are more preferred by the students. On the other hand, there are less number of applicants in some of the MTECH programs such as MTECH programs in Chemical Engineering, Chemical Engineering (Specialization in Energy Resources and Sustainable Environmental Engineering), Advanced Material Science and Technology, Metallurgy and Materials Technology over the past few years.
In view of the above, following measures are recommended for approval of the Senate:
(a) Increase in sanctioned intake of the more preferred MTECH programs, such as MTECH in Mirco-electronics and VLSI and MTECH in Structural Engineering
(b) Decrease in sanctioned intake / merger of two or more non-preferred MTECH programs such as MTECH programs in Chemical Engineering, Chemical Engineering (Specialization in Energy Resources and Sustainable Environmental Engineering), Advanced Material Science and Technology, Metallurgy and Materials Technology.
DPAC of non-preferred MTECH programs are requested to deliberate on the same and submit their views before the next PGAC.

Item # 12 **To consider the matter of re- evaluation of marks in Internet of Things (CSE 814) of Soumik Samanta (Roll no. 18CS 8127).**

Since the student has already been issued a provisional certificate long time ago, the matter is not recommended by the UGAC. However, the Senate may give its wise opinion on the matter (See Annexure III).

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Item # 13 **To consider the matter regarding an email application dated 30.08.2022 on not having original signature of the Controller of Examinations on the grade card of B.Tech third semester 2005 – 2006 supplementary examination issued on May 09, 2006 to Himanshu Kumar Sarkar (Roll no. 04 / 526, Regn no. 20040200 of the department of Information Technology.)**

A duplicate grade card in existing format may be issued on return of the original unsigned grade card of B.Tech third semester 2005 – 2006 supplementary examination issued on May 09, 2006 to Himanshu Kumar Sarkar (Roll no. 04 / 526, Regn no. 20040200 of the department of Information Technology).

Item # 14 **To consider the matter regarding audit course XE9030 of PG program.**

Resolved that

- Attending all sorts of research related seminars like PhD defence, pre-foreign visit of the faculty member etc. by the department shall be made mandatory for the MTECH students.
- Grades as satisfactory or not satisfactory will be recorded in the marksheet.

The meeting ended with vote of thanks to the Chairman.

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National Institute of Technology
Durgapur-713209 India

Dean (Academic Courses)
Date: 31.08.2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN BIOTECHNOLOGY

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in ______ Senate # _______________ # Item no: ______

DEPARTMENT OF BIOTECHNOLOGY

Program Name: Bachelor of Technology in Biotechnology

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR BIOTECHNOLOGY- B.TECH.
L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week
C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III								
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CHC331	Process Calculation and Thermodynamics	3	1	0	4.0	4
3	BTC301	Cell biology and Genetics	3	1	0	4.0	4
4	BTC302	Microbiology and Bioprocess Technology	3	1	0	4.0	4
5	BTC303	Biochemistry and Enzyme Technology	3	0	0	3.0	3
6	BTS352	Biochemistry Laboratory	0	0	3	1.5	3
7	BTS351	Microbiology Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	BTC401	Molecular Biology and Recombinant DNA Technology	3	1	0	4.0	4
2	CHC431	Unit Operation of Chemical Engineering- I	3	1	0	4.0	4
3	BTC402	Immunology	3	1	0	4.0	4
4	CSC431	Programming and Data Structure	3	0	0	3.0	3
5	YYO44*	Open Elective - 1	3	0	0	3.0	3
6	BTS451	Cell Biology and Genetics Laboratory	0	0	3	1.5	3
7	CHS481	Unit Operations of Chemical Engineering-I Laboratory	0	0	3	1.5	3
8	CSS481	Programming and Data Structure Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	BTC501	Biochemical Reaction Engineering and Bioreactor Design	3	1	0	4.0	4
2	BTC502	Cell and Tissue Culture	3	1	0	4.0	4
3	BTC503	Bioseparation and Biochemical Analysis	3	1	0	4.0	4
4	CHC531	Unit Operations of Chemical Engineering-II	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	BTS551	Immunology Laboratory	0	0	3	1.5	3
7	BTS552	Bioprocess Technology Laboratory	0	0	3	1.5	3
8	CHS581	Unit Operations of Chemical Engineering Laboratory- II	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	15	4	9	23.5	28

Semester - VI							
Sl.	Code	Subject	L	T	S	C	H
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	BTC601	Bioinformatics	2	1	0	3.0	3
3	CSC631	Database Management System	2	1	0	3.0	3
4	CHC631	Process Control and Instrumentation	2	1	0	3.0	3
5	BTE610 --	Depth Elective - 1	3	0	0	3.0	3
6	BTE610 --	Depth Elective - 2	3	0	0	3.0	3
7	BTS651	Molecular Biology and rDNA Technology Laboratory	0	0	3	1.5	3
8	BTS652	Bioinformatics Laboratory	0	0	3	1.5	3
9	CSS681	Database Management System Laboratory	0	0	3	1.5	3
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	BTE710 --	Depth Elective - 3	3	0	0	3.0	3
3	BTE710 --	Depth Elective - 4	3	0	0	3.0	3
4	BTE710 --	Depth Elective - 5	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	BTS751	Bioseparation and Biochemical Analysis Laboratory	0	0	3	1.5	3
7	BTS752	Cell and Tissue Culture Laboratory	0	0	3	1.5	3
8	BTS753	Biochemical Reaction Engineering Laboratory	0	0	3	1.5	3
9	BTS754	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
10	BTS755	Project - I	0	0	3	1.0	3
		TOTAL	15	0	14	21.5	29
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	BTE810 --	Depth Elective - 6	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	BTS851	Project - II	0	0	15	5.0	15
5	BTS852	Project Seminar	0	0	0	1.0	0
6	BTS853	Viva Voce	0	0	0	1.0	0
		TOTAL	9	0	15	16.0	24

CURRICULUM AND SYLLABUS FOR B.TECH IN BIOTECHNOLOGY

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45.0	22.0	22.5	23.5	22.5	21.5	16.0	173.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF BIOTECHNOLOGY
BTE610	Animal Biotechnology
BTE611	Industrial Microbiology
BTE612	Nutraceutical and Nutrigenomics
BTE613	Human Genomics
BTE614	Molecular Virology
BTE615	Biometallurgy
BTE616	Nanobiotechnology
BTE617	Marine Biotechnology
BTE618	Folding, Misfolding and Diseases
BTE619	Engineering Resistance in Plants

7th Semester

	DEPARTMENT OF BIOTECHNOLOGY
BTE710	Molecular Plant Pathology
BTE711	Cancer Biology and Cell Signaling
BTE712	Food Biotechnology
BTE713	Biopharmaceutical Process Design
BTE714	Bioenergy
BTE715	Project Engineering for Biotechnology
BTE716	Structural Biology
BTE717	Environmental Biotechnology
BTE718	Proteomics and Protein Engineering
BTE719	Molecular Modelling and Drug Design
BTE720	Nanotherapeutics
BTE721	Biomaterials
BTE722	Vaccine Technology
BTE723	Stem Cell Biology
BTE724	Application of Molecular Cloning

8th Semester

	DEPARTMENT OF BIOTECHNOLOGY
BTE810	Plant Developmental Biology
BTE811	Bioprocess Plant and Equipment Design
BTE812	Medical and Pharmaceutical Biotechnology
BTE813	GM Crops
BTE814	Bioethics and IPR
BTE815	Environmental Microbiome

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I								
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points,						

	Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course	CO1: To realize and apply the fundamental concepts of physics such as superposition						

Outcomes	principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5)						

<table>
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ii. Bioinorganic Chemistry: Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3)
iii. Inorganic Materials: Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2)
iv. Organometallic Chemistry: π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4)
PHYSICAL CHEMISTRY
i. Thermodynamics: 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4)
ii. Chemical Kinetics: 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4)
iii. Electrochemistry: Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2)
iv. Absorption: Physical and Chemical absorption, Absorption isotherms. (1)
v. Catalysis: Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
</td></tr>
<tr><td>Text Books, and/or reference material</td><td>
<u>Suggested Text Books:</u>
(i) Physical Chemistry by P. Atkins, Oxford
(ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu.
(iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall
<u>Suggested Reference Books:</u>
Organic Chemistry:
(i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press
(ii) Engineering Chemistry: Wiley
(iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan
Inorganic Chemistry:
(i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education
(ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein.
(iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford
Physical Chemistry:
(i) Physical Chemistry by G.W Castellan
(ii) Physical Chemistry by P. C. Rakshit
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Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1^{st}, 2^{nd}, 3^{rd} and 4^{th} quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)						
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))
NIL	CE+EA

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes

- CO1: To learn basic analytical techniques useful for engg applications.
- CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance.
- CO3: Learn chromatographic separation methods.
- CO4: Applications of spectroscopic measurements.

Topics Covered

i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter.
ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH.
iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry
iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration.
v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc.
vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone.
vii. Synthesis of polymer: polymethylmethacrylate
viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution.
ix. Chromatography: Separation of two amino acids by paper chromatography
x. Determination of saponification value of fat/ vegetable oil

<u>Suggested Text Books:</u>

1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall
2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu
3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra

<u>Suggested Reference Books:</u>

1. Practical Chemistry By R.C. Bhattacharya
2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	**WORKSHOP PRACTICE**	PCR	**0**	**0**	**3**	**3**	**1.5**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes

- CO1: Study and practice on machine tools and their operations
- CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
- CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
- CO4: Develop basic electrical engineering knowledge for house wiring practice

Topics Covered

M/c shop & Carpentry shop -- 3X3= 9hrs.

- Introduction on machining process.
- Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
- Introduction to woods- Types, structure, disease and defect of wood.
- Introduction to wood working machines and tools.
- Making of dovetail joint and bridle joint.

Welding Shop & Sheet metal -- 3X3= 9hrs.

- Introduction to welding.Safety and precautions in welding.
- Formation of weld bead by SMAW on mild steel flat.
- Formation of weld bead by oxy-fuel welding on mild steel flat.
- Introduction to sheet Metal works.
- Tools and Machines used in sheet metal works.
- Concept of development, marking out of metal sheets.
- Cutting and joining of metal sheets.
- Safety precautions, General warning needed in the shop floor.

Black smithy & Foundry -- 3X3= 9hrs.

- Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
- Safety and precautions in blacksmithy.
- Making of bars of different cross-sections.
- Making of hexagonal headed bolts.
- Forge welding.
- Introduction to Foundry Technology.
- Preparation of sand mould using Solid/Split Pattern.

Fitting & Electrical shop -- 3X3= 9hrs.

- Introduction to hand metal cutting tools with specifications, nomenclature and their use.
- Marking tools, measuring tools and their use.
- Fitting of joints of mild steel flats.
- Introduction to electrical hazards and safety precaution.

	• Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))						
NIL	CT+EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra,						

	Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket

- Batting gripping & Stance, Bowling gripping technique.
- Batting front foot defense& Drive.
- Batting Back foot defense& Drive.
- Batting Square cut.
- Bowling medium pace, Bowling off break.
- Fielding drill, Catching (Short & High).
- Rules & Regulation.

BADMINTON

- Basic introduction about Badminton and Badminton court.
- Racket parts, Racket Grip, Shuttle Grip.
- Basic stance, Basic Footwork, Shadow practice (Full court movement).
- Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm.
- Match practice (Single & Double).
- Rules & Regulation.

TABLE TENNIS

- Introduction of Table Tennis.
- Basic Stance and Grip (Shake hand & Pen hold).
- Service Basic.
- Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Rules and their interpretations.
- Table Tennis Match (Singles & Doubles).

NCC

- FD-1 General Introduction and words of command.
- FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt.
- FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing.
- FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out.
- FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt.
- FD-7 Turning on the March and Wheeling.
- FD-12 Parade practice.

TAEKWONDO

- Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc.
- Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc.
- Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc.
- Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc.

NSS

	• Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of set theory, differential equations, and probability.	CT+MT+EA

Course Outcomes	
	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.

Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
	Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CSC01</td><td>INTRODUCTION TO COMPUTING</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of computer.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates.
CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators.
CO3: Develop conditional and iterative statements to write C programs.
CO4: Exercise user defined functions to solve real time problems
CO5: Inscribe C programs that use Pointers to access arrays, strings and functions.
CO6: Exercise user defined data types including structures and unions to solve problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2]
Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1]
Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2]
Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1]
C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2]
Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8]
Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5]
Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5]
Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10]
Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium 1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons						

	1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback

	7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	ELECTRICAL TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))					
NIL		CT+MT+ EA					
Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts. • CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment’s • CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.						
Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm’s laws, Kirchhoff’s laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin’s Theorem, Norton’s Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin’s theorem, Norton’s theorem, maximum power transfer theorem, solution of networks with AC						
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis,

<table>
<tr><td></td><td>TCA; overall degradation of proteins and lipids
d) Biosynthesis of Macromolecules
Generation of ATP (ETS), Generation of Glucose (Photosynthesis)
3. Microbiology (5)
a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases
b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc,
c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve
d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle
4. Immunology (5)
a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system
b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody
c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination
d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell
5. Molecular Biology (5)
a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear
b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin
c) Central Dogma (Replication, Transcription and Translation)
d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning
6. Bioprocess Development (5)
a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation
b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation
Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki
c) Microbial sterilization techniques and kinetics
Introduction to sterilization, dry and moist sterilization
d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions
e) Material and energy balance for biological reactions - Stoichiometry</td></tr>
<tr><td>Text Books, and/or reference material</td><td>1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD.
2. Biochemistry by Lehninger. McMillan publishers
3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill
4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992
5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition,</td></tr>
</table>

	Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XXC01</td><td>The Constitution of India and Civic Norms</td><td>PCR</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India.
CO2: Aware of the fundamental rights and duties as a citizen of the country.
CO3: Enable to know the civic norms to be followed according to the Indian constitution</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Historical background of the Making of Indian Constitution (1 Hour)
2. Preamble and the Philosophical Values of the Constitution (1 Hour)
3. Brief Overview of Salient Features of Indian Constitution (1 Hour)
4. Parts I & II: Territoriality and Citizenship (1 Hour)
5. Part III: Fundamental Rights (2 Hours)
6. Part IV: Directive Principles of State Policy (1 Hour)
7. Part IVA: Fundamental Duties (1 Hour)
8. Union Government: President, Prime Minister and Council of Ministers (2 Hours)
9. Parliament: Council of States and House of the People (1 Hour)
10. State Government: Governor, Chief Mister and Council of Ministers (1 Hour)
11. State Legislature: Legislative Assemblies and Legislative Councils (1 Hour)
12. Indian Judiciary: Supreme Court and High Courts (1 Hour)
13. Centre-State Relations (1 Hour)
14. Reservation Policy, Language Policy and Constitution Amendment (1 Hour)</td></tr>
</table>

Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]
Text and/or reference material	1)... Engineering Drawing and Graphics – K Venugopal 2)... AutoCAD — George Omura 3)... Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS51</td><td>COMPUTING LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques
• CO2: To detail out the operations of strings
• CO3: To understand structure, union
• CO4: Application of C-programming to solve various real time problems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
1. Assignments on expression evaluation
2. Assignments on conditional branching, iterations, pattern matching
3. Assignments on function, recursion
4. Assignments on arrays, pointers, parameter passing
5. Assignments on string using array and pointers
6. Assignments on structures, union</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Let us C by Kanetkar
2. C Programming by Gottfried
3. Introduction to Computing by Balaguruswamy
4. The C-programming language by Dennis Ritchie
Reference Books:
1. Computer fundamental and programming in C by P Dey and M. Ghosh
2. Computer fundamental and programming in C by Reema Thareja
3. programming with C by Schaum Series</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS 51</td><td>Basic electronics Lab</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire idea about basic electronic components, identification, and behavior.
• CO2: To determine IV characteristics of these Circuit elements for different applications.
• CO3: Learn to analyze the circuits and observe and relate input and output signals.</td></tr>
<tr><td>Labs Conducted.</td><td colspan="7">1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments.
2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it.
3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms.
4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.
5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs
6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs
7. Transistor as a Switch: study and perform transistor as a switch through NOT gate
8. Zenner diode as voltage regulator
9. To study clipping and Clamping circuits
10. To study different biasing cirtis.
11. Study of CE amplifier and observe its frequency response.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al.
<u>Reference Books</u>:
1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill
2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: understand the principle of superposition. • CO2: understand the principle of maximum power transfer • CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: understand the calibration of energy meter. • CO5: understand open circuit and short circuit test of single-phase transformer. • CO6: analyze RLC series and parallel circuits • CO7: understand three phase connections. • C08: understand determination of B-H curve						
Topics Covered	**List of Experiments:** 1. To verify Superposition and Thevenin's Theorem. 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit 9. Determination of B-H Curve for magnetic material						
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma, H U Ezea 2. Laboratory Courses in Electrical Engineering (5th Ed) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Pub.)						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3

CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>XXS-52</td><td>Co-curricular Activities</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Pre-requisites</td><td colspan="7">Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)</td></tr>
<tr><td>NIL</td><td colspan="7">CE + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Social Interaction: Through the medium of sports
• CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them
• CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.
• CO4: Personality development through community engagement
• CO5: Exposure to social service</td></tr>
<tr><td>Topics Covered</td><td colspan="7">YOGA
• Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana.
• Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra.
• Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana.
• Meditation- ‘Om’meditation, Kundalini or Chakra Meditation, Mantrameditation.
• Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose).
• Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari.
• Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha.
• Kriya- Kapalabhati, Trataka, Nauli.
ATHLETICS
• Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing
• Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through.
• Field events marking.
• General Rules of Track & Field Events.
BASKETBALL
• Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw.</td></tr>
</table>

	• Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with

	rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service. • Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

THIRD SEMESTER

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td colspan="2">MATHEMATICS-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic knowledge of topics included in MAC01 & MAC02.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">

CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.
</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]
Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange’s interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson’s 1/3 rule for numerical integration; Euler’s method and modified Eular's methods for solving first order differential equations. [14]
Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy’s integral theorem; Cauchy’s integral formula; Taylor’s theorem, Laurent’s theorem (Statement only); Singular points and residues; Cauchy’s residue theorem. [17]
Optimization:
Mathematical Preliminaries: Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2]
Linear Programming Problem (LPP): Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. An Elementary Course in Partial Differential Equations-T. Amarnath
2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar&R.K.Jain.</td></tr>
</table>

	3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig Suggested Reference Books: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2		2			2	2	3
CO2	1	2	1	1			3		2	1		3
CO3	3			2		1	2		2			3
CO4	3	3	3	2			1	2	1		2	3

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC331	PROCESS CALCULATIONS AND THERMODYNAMICS	PEL	3	0	0	3	3
Mathematics I and Mathematics II		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: To develop the concept of dimension and unit conversion to check dimensional consistency of balanced equation • CO2: Learn basic laws about the behavior of gases, liquids and solids and some basic mathematical tools. • CO3: To Establish mathematical methodologies for the computation of material balances and energy balances with and without chemical reaction • CO4: To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries. • CO5: To analyze and interpret data, to identify, formulate, and solve engineering problems.
Topics Covered	Module - I (10 hrs) • Significance of Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis Mathematical Requisites: Use of log-log and semi-log graph paper, Triangular Diagram. • Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another. • Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial volume, Dalton's law and Amagat's law and Numerical problems on their applications. • Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications.

	• Ideal & non-ideal solutions, Raoult's law, Henry's law and their applications in numerical problems. Module – II (10 hrs) • Material Balances with and without chemical reaction: Material balances in crystallizers, gas - liquid absorbers, evaporators, distillation plant. Systems with recycle,drying, extraction. • Energy Balance: Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, liquids and gases. Heat of fusion and vaporization • Enthalpy calculation for systems with Chemical Reaction, Thermo-chemistry, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Adiabatic Flame Temperature, Theoretical Flame Temperature. Module – III (10hrs) • Scope of thermodynamics, Terminology and fundamental concepts. Microscopic and macroscopic view. State and path functions, thermodynamics processes, Zeroth and First law of thermodynamics: Applications of first law to close and open system.Limitations of first law, Heat pump, heat engine, Second law of thermodynamics: Reversibility and irreversibility, Carnot cycle, concept and estimation of entropy, third law of thermodynamics, Clausiusinequality,Gibb's and Helmholtz free energy. Module – IV (10 hrs) • PVT behavior of pure substance, Equations of state for ideal and real gases, cubic andvirial equation of state, problems, Compressibility factor,thermodynamic properties of pure substances. • Refrigeration of gases: Refrigerator, Co-efficient of performance, capacity of refrigerator, Vapour compressioncycle, Choice of refrigerants.
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Process Calculations, D.C. Sikdar, HI Learning Private Limited, 2013 2. Stoichiometry and Process Calculations, K. V. Narayanan, B. Lakshmikutty, PHI Learning (2017) 3. Stoichiometry, Bhatt and Vora, Tata McGraw Hill Companies. 4. Introduction to Chemical Engineering Thermodynamics, GopinathHalder, Prentice-Hall Of India Pvt. Limited, 2009 5. A Textbook of Chemical Engineering Thermodynamics, Narayanan K.V, Prentice Hall India Learning Private Limited; 2nd edition, 2013 Suggested Reference Books: 1. Unit Operations–Chemical Process Principles – Part-I - Haugen, Wartson&Ragatz (CBS) 2. Basic Principles and Calculations in Chemical Engineering – Himmelblau ((Prentice Hall of India) 3. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill) 4. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley)

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2	1	1			1	3	1	1	3
CO 2	3	3	2	1	1			1	3	1	1	3
CO 3	3	3	3	1	1			1	3	1	3	3

CO 4	3	3	3	2	1		1	2	3	1	3	3

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 301	CELL BIOLOGY AND GENETICS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	CO1: To understand the basic organization of cells and organisms and the tools needed to study them CO2: To understand the basic processes of the cell machinery, cell-cell interaction and the eukaryotic cell cycle. CO3: To apply the knowledge of cell process regulation and cell cycle in understanding the use of a cell as a biological tool for manufacturing biomolecules. CO4: To learn the fundamentals of Genetics and its applications. CO5: To solve problems associated with genetic diseases and their transmission from one generation to the next
Topics Covered	**Classical Genetics:** Mendelian inheritance; Euploidy and aneuploidy (4) Genetic interactions (2) **Molecular Genetics**-Split and Overlapping genes; Transposons &Retrotransposons; Mutation (6) DNA Repair and human diseases (4) Recombination (2) **Internal Organization of the cell**: Cells as experimental models, Cells and cellular organelles, Tools of cell biology- Microscopy and cell Architecture, Purification of cells, Membrane structure, Membrane Transport of small molecules and electrical properties of membranes (8) **Cytoskeleton and cell movement:** Structure and organization of actin filaments, Actin myosin and cell movement, intermediate filaments, microtubules, microtubule motors and movements, cell-cell interactions (6) **Cell signalling** Signaling molecules and their receptors, function of cell surface receptors, pathways of intracellular signal transduction, signal transduction and the cytoskeleton, signalling in development and differentiation (6) **Cell cycle and cancer** Eukaryotic cell cycle, meiosis and fertilization, stem cells, Development and causes of cancer, oncogenes, tumor suppressor genes (4)
Text Books, and/or reference material	Suggested Text Books: 1. Molecular Biology of Cell by Albert et.al. John Wiley & Sons 2. The Cell by Cooper. ASM Press 3. M.W.Strickberger: Genetics, Pearson. 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, Suggested Reference books: 1. Cell and Molecular Biology by Karp. John Wiley & Sons1992 2. Stratchan& Read: Human Molecular Genetics 3. David Freifelder: Microbial Genetics, Jones and Bartlett Publisher Inc. 1987

	4. In Introduction to genetic analysis, Griffiths, Miller, Suzuki, Lewontin and a. Gelbart, Freeman and Company

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2										2
CO2		2		2								
CO3	2	2	3	2	1		3					2
CO4	1	2		2								1
CO5		2	2									2

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 302	MICROBIOLOGY AND BIOPROCESS TECHNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01 (LIFE SCIENCE)		CT+MT+EA					

Course Outcomes	CO1: To develop knowledge on different types of microorganisms including viruses and microscopy for the visualization of microorganisms, their characteristic features as well as internal and external structures and their functions. CO2: To impart an understanding on microbial classification and taxonomy, microbial community and interactions, microbial nutrition, nutritional types, growth media, growthin different systems, and control of microorganisms using various physical and chemical treatments including antimicrobial drugs. CO3: To develop knowledge on microbial metabolism, energy transduction mechanisms, and microbial genetics CO4: To acquire experimental know how of microbial production of various industrial products such as alcohol, antibiotics, amino acids, vitamins exopolysaccharides, enzymes, etc. from industrial strains. CO5: To illustrate the upstream and downstream processing for product recovery and purification.
Topics Covered	**PART A: Microbiology** **Introduction to microbiology:** History and scope of microbiology, major contribution and events in microbiology, different types of microorganisms – characteristic features, microbes and diseases, microbes in human welfare.[**2]** **Microbial structures:** Different types of microscopy, preparation and staining of specimens, microbial shape, size, arrangements, overview of procaryotic and eucaryotic cell – internal and external structures, cytoplasmic matrix, nucleoid, plasmids, ribosomes, flagella, pilli, fimbrie, spores, bacterial and archaebacterial cell walls and cell membranes, Viruses – types, structures, multiplications [**4]** **Microbial classification and taxonomy:** Domains of life, classification, taxonomic ranks, techniques for determining microbial taxonomy and phylogeny, prokaryotic phylogeny and

	diversity, microbial community and interactions – Mutualism, Cooperation, Commensalism, Predation, Parasitism, Amenalism, Competition. Normal microbiota of human body. [**3]** **Microbial nutrition, growth and control:** Common nutrient requirements, nutritional types, uptake of nutrients by cell, culture media, pure culture, microbial growth – batch culture and continuous culture, growth curve, measurement of growth, influence of environmental factors on growth, control of microorganisms by physical and chemical agents, Antimicrobial drugs – general characteristics, narrow-spectrum and broad-spectrum drugs, inhibitors of cell wall synthesis, nucleic acid synthesis and protein synthesis, metabolic antagonists, Drug resistance. **[5]** **Microbial metabolism:** Energy release and conservation, chemoorganotrophic fueling processes, aerobic respiration, glycolysis, TCA cycle, electron transport and oxidative phosphorylation, anaerobic respiration - nitrate and sulphate reduction, fermentations, chemolithotrophy, phototrophy [3**]** **Microbial genetics:** Conjugation, Transduction, Transformation **[4]** **PART B: BIOPROCESS Technology** A) Introduction to Fermentation Technology: Microbial Culture systems; Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; The development of Inoculum for Industrial fermentations; Starter Cultures; Downstream Processing and fermentation economics. .... **[4]** B) Commercial Strain Development & Microbial Processes: Sources of industrial cultures and maintenance. Alcoholic fermentation: Production of Industrial Alcohol – Fermentation mechanism. Recent developments, brewing and malting, manufacture of wine and other distilled liquors. Cellular control regulating production of microbial metabolites – Primary and Secondary metabolite – Induced mutation technique – Analogue resistant mutant – Catabolic derepressed mutants – Genetically engineered strain – Protoplast fusion technique. Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. **[5]** C) Microbial production of nucleosides and nucleotides: i) Introduction ii) Classification of methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. ....**[3]** D) Microbial production of Vitamins: 1) Vitamin B12 - Organisms used, production method- process, recovery and assay. 2) Vitamin C - Organisms used, production method, process, recovery and assay. **[3]** E) Lectures Microbial Production of Antibiotics : Organism used, production process and recovery of- 1) Bacitracin & 2) Chloramphenicol **[2**] F) Lectures Microbial Production of acids, viz., citric, lactic, Acetic acid, vinegar and gluconic acid. Mechanism of each fermentation, their uses. its spoilage and prevention **[2]** G) Production of Amino acids (Lysine and glutamic acid) and Antibiotics (Pencillin, Streptomycin and Tetracyclines) and its new Developments ....**[2]**
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Prescott, Harley and Klein's Microbiology – McGraw Hill 2. Microbiology by Pelczar, Chan and Krieg, Tata Mc Graw Hill 3. L.E. Casida. Jr, Industrial Microbiology, New Age International Publisher 4. W. Crueger, AnneliseCrueger, Biotechnology: A Textbook of Industrial Microbiology, Pnima Publishing Corporation 5. Fermentation microbiology and biotechnology. Ed. E.M.T. El-Mansi , C.F.A. Bryce, B. Dahhou, S. Sanchez, A.L. Demain, A.R. Allman. 3rd ed. Taylor and Francis. <u>Suggested Reference Books:</u> 1. Microbiology by Tortora, Funke and Case 2. Brock Biology of Microorganisms

	3. General Microbiology by Hans G Schlegel, Cambridge 4. Atkinson. B and Marituna. F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ.Ltd.4 5. James E Bailey, David F., Ollis, Biochemical engineering fundamentals, second edition. McGraw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	1	-	-	-	-	-	-	3
CO2	2	2	1	2	2	2	2	1	-	-	1	2
CO3	2	2	2	2	2	1	2	2	2	1	-	3
CO4	3	2	2	2	2	2	2	1	2	-	1	2
CO5	3	3	2	2	2	2	2	2	2	1	2	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC303	BIOCHEMISTRY AND ENZYME TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	**CO1:** To understand the principles of bioenergetics and to correlate them with the metabolic pathway. **CO2:** To impart an understanding on the fates of macromolecules during metabolism. **CO3:** To provide an understanding on the importance and synthesis of energy currency molecule, ATP. **CO4:** To interpret the regulation in the metabolic pathway and to study the role of hormones in the metabolic pathway. **CO 5:** To understand mechanism and kinetics of enzyme action and their regulation for application of enzymes in living system and for industrial purpose.
Topics Covered	**Module 1** **(3+2)5** Biomolecules, Vitamins Principles of Bioenergetics **Module 2** **Carbohydrate and its metabolism** **5** **Carbohydrate Biosynthesis** - Gluconeogenesis, Biosynthesis of glycogen, starch, Sucrose , Photosynthetic Carbohydrate Synthesis, **Glycolysis and catabolism of hexoses -** Glycolysis, pentose phosphate pathway of glucose oxidation, Citric acid cycle, regulation of citric acid cycle, glyoxylate cycle . Role of hormones in metabolism **Oxidative Phosphorylation and Photo Phosphorylation** - Oxidative Phosphorylation, Regulation of Oxidative Phosphorylation, Photosynthesis **Module 3** **3** **Lipid and its metabolism** O**xidation of Fatty acids** - Transport of fatty acid, beta-oxidation, Ketone bodies **Lipid Biosynthesis** - Biosynthesis of fatty acids

	Module 4 **3** **Protein and its metabolism** **Amino acid oxidation and production of Urea** - Metabolic fates of amino groups, Nitrogen excretion and the urea cycle, Pathways of amino acid degradation Nitrogen metabolism, Biosynthesis of amino acids, **Module 5** **2** **Nucleic acid and its metabolism** Biosynthesis and degradation of Nucleotides **Module 6** **12** **Enzyme Technology and Vitamins** **Enzymes:**Nomenclature of enzymes, Enzyme kinetics, Mechanism of enzymatic, Catalysis, Active site, Activators and inhibitors, Coenzymes, Isoenzymes, Michaelis-Menten equation, Km and Vmax value, Regulation of enzyme activity (single-substrate and multi-substrate reactions). Vitamin's as coenzyme **Production of enzymes and immobilisation** : Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis. Enzyme immobilization: Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme. Engineering of Enzymes **Application of enzyme** in leather industry, detergent industry, dairy industry; Lignocellulose degrading enzymes.
Text Books, and/or reference material	Suggested Text Books: 1. Biochemistry by LubertStryer. W. H. Freeman & Company, NY 2. Biochemistry by Lehninger. McMillan publishers Suggested Reference Books: 1. Biochemistry, Voet&Voet 2. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press 3. Enzyme technology by Chaplin and Bucke. Cambridge Univerity Press

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	2	1	1	1	3
CO2	3	3	3	3	3	2	2	3	1	1	1	3
CO3	3	3	3	3	2	3	1	1	1	1	1	3
CO4	3	3	2	3	3	3	1	1	1	1	1	3
CO5	3	3	3	3	3	3	3	3	3	3	1	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS351	MICROBIOLOGY LABORATORY	PEL	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To learn and become familiar with types of culture media, preparations of culture media, sterilization procedures, types of equipments. CO2: To understand the concept of sterility, working principles and applications of instruments: autoclaving, laminar air flow hood etc. CO3:To learn about the isolation and maintenance process of bacterial cultures. CO4: To apply the understanding of the cultural and morphological characteristics of microorganisms grown in pure culture.Applications in Antimicrobial effect and CO5: To interpret microbial growth phases its kinetics specific growth rate.to determine the effects of chemicals on bacteria and to understand the quality of water.
Topics Covered	**Microbial culture media preparation:** Basic concepts of nutrition materials in media, classes of culture media, how to prepare growth media. **The control of microbial growth :** To study the methods of sterilization: autoclaving, laminar air flow hood, irradiation, filtrations, chemical and gas. **Isolation of microorganisms from an environment of choice :** To demonstrate the ubiquity and diversity of microbes in the environment, samples from immediate areas of the environment will be obtained and cultured and dilution methods. **Isolation and Maintenance of pure cultures :** To study the different techniques of isolation and maintenance of pure cultures: subculturing, streak plate method, pour plate method, spread plate method. **Bacterial morphology and staining :** To study the physical properties and differentiation of microorganisms with the help of different staining procedures: differential and structural staining. Techniques of Gram staining, endospores staining, microscopic study. **Estimation of coliform bacteria:** To study the estimation of coliform bacteria in water by MPN (most probable number) test. **Study of bacterial growth:** To study the growth pattern of bacteria, specific growth rate calculation, different growth phases of bacteria. **Antimicrobial activity study:** To determine the antibiotic susceptibility via sensitivity disk methods, calculation of zone of inhibition.
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Benson HJ. 2002. Microbiological applications: a laboratory manual in general microbiology: McGraw-Hill New York, NY. 2. Harley JP. 2004. Laboratory exercises in microbiology: McGraw-Hill Science/Engineering/Math <u>Suggested Reference Books:</u> 1. Brown AE. 2009. Benson's Microbiological Applications: Laboratory Manual in General Microbiology, Short Version: McGraw Hill 2. Madigan MT, Martinko JM, Dunlap PV, Clark DP. 2012. Brock biology of microorganisms: Pearson/Benjamin Cummings. 3. Pollack RA. 2004. Laboratory exercises in microbiology, 3e. Recherche 67: 02

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	1						1					1
CO2	2											1
CO3		2			1							1
CO4			2			1	1					
CO5	1		2				2					2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS352	BIOCHEMISTRY LABOARTORY	PCR		0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To design , analyze and solve problems and learn to plot graph and interpret data CO2: To develop skills to perform experiments and have hands on training. CO3: To apply the results and data to solve problems in daily activities and industry.
Topics Covered	1. To prepare Tris-HCl Buffer with a specific pH (eg. pH 8.8) 2. Qualitative and quantitative estimation of carbohydrates 3. Qualitative and quantitative estimation of aminoacids and determination of the unknown concentration of protein concentration by plotting a standard curve of BSA using Bradford reagent 4. Ammonium sulphate precipitation and dialysis for a protein 5. Separation and Identification of Amino acids by Paper Chromatography and Thin Layer Chromatography 6. Analysis of Protein purity and determination of molecular weight of pure protein by SDS PAGE and Coomassie Brilliant blue staining of proteins on SDS gel 7. Extraction of Enzyme Tyrosinase from commercially available mushrooms and Assay of Enzyme Tyrosinase with determination of specific activity of Enzyme Tyrosinase 8. Effect of substrate concentration on the activity of Enzyme Tyrosinase and determination of MichelesMenton parameters of Enzyme Tyrosinase 9. Effect of inhibitor concentration on the activity of Enzyme Tyrosinase
Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry by David T Plummer Suggested Reference Books: 2. Biochemistry by Voet and Voet

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	3	3	3	3	3	2	3
CO2	3	3	2	3	2	3	3	3	3	3	2	3
CO3	3	3	2	3	3	3	3	3	3	3	2	3

FOURTH SEMESTER

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC401</td><td colspan="2">MOLECULAR BIOLOGY AND rDNA TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01 Life Science
BTC301 Cell Biology and Genetics
BTC303 Biochemistry and Enzyme Technology</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Students will acquire basic understanding of molecular biology topics: nucleic acid structure and chemistry; organization of genome in chromosomes; regulation of replication, transcription, translation and DNA repair.
CO2: Students will acquire knowledge of recombinant DNA techniques on: nucleic acid amplification and gene cloning; manipulation of DNA sequences; preparation and screening of nucleic acid libraries; gene silencing; analysis of variations in genome sequence.
CO3: Students will be proficient in applying basic understanding of molecular biology topics in analyzing and solving problems related to recombinant DNA technology.
CO4: Students will be able to design strategies to solve problems related to recombinant DNA technology.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">1. Nucleic acid structure: Nucleotides and nucleic acids, DNA structure, different forms of DNA, unusual DNA structure, different types of RNA, RNA structure. [3]
2. Nucleic acid chemistry: Denaturation and renaturation, hybridization, nonenzymatic transformation (Mutation) – spontaneous and induced, point mutation - transition, transversion, mutation involving more than one base pairs, insertion, deletion, frame shift mutation, forward and back mutation, null mutation, Loss-of-function and gain-of-function mutation, silent mutation, DNA sequencing. [4]
3. Chromosome organization: Chromosomal elements – genes and intergenic regions, regulatory sequences; DNA supercoiling, linking number, Chromosome structure: Histones, Non-histones, Nucleosome, Chromatin. Chromosome structure in prokaryotes & eukaryotes. [4]
4. DNA replication and repair: Central dogma, DNA replication in prokaryots and eukaryots – set of fundamental rules, DNA polymerases, proteins and enzymes involved in replication, process, accuracy. [4]
5. Transcription and post-transcriptional processing: DNA-dependent RNA synthesis in prokaryotes and eukaryotes, RNA polymerases, transcription process, termination, selective inhibition, RNA processing – capping, splicing of introns, differential RNA processing; RNA-dependent synthesis of RNA and DNA. [4]
6. Protein synthesis – translation: Genetic code, ribosome, transfer RNA, protein biosynthesis stages – attachment of amino acid to specific tRNA, initiation, elongation, termination, folding and processing; inhibition of protein synthesis. [4]
7. DNA repair: DNA repair – multiple repair systems. [3]</td></tr>
</table>

	8. Regulation of gene expression: Regulation of gene expression in bacteria - operon concept; Regulation of gene expression in eukaryotes, hormonal control of gene expression in eukaryotes. [3] 9. Introduction to recombinant DNA and Gene Cloning Tools of recombinant DNA: Vectors; plasmid, bacteriophage viral vectors, cosmids, yeast artificial chromosome. Expression vectors, and selection of suitable Host. [5] 10. Restriction endonucleases and other enzymes use and mechanism of action and analysis, Genomic DNA and cDNA library preparation. Strategies for engineered vectors use and regulation for enhanced gene expression and purification. [5] 11. Screening and selection of clone with desired gene and protein of interest: Colony and plaque hybridization. antibody based assay, Protein activity. Application of gene cloning and DNA Analysis. [3] 12. Molecular probes: Preparation of molecular probes DNA probes, RNA probes, radioactive labeling, Non-radioactive labeling, use of molecular probes in DNA fingerprinting. Southern blotting, Northern blotting, Western blotting, In-situ hybridization. [4] 13. MOLECULAR TECHNIQES: Polymerase chain reaction, different types and their use. Antisense RNA technology, Site directed mutagenesis, Use of RFLP, SNP and Microarray. [4]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Gene IX by B. Lewin, Pearson 2. Molecular biology of the cell by Albertset. al., Garland science <u>Suggested Reference Books:</u> 1. Molecular Biology of the Gene, 7th edition 2013. Watson et. al. Published by Pearson. 2. Cell and molecular Biology, Concepts and experiments Gerald Karp, John Wiley and Sons. 3. The Cell - A molecular approach, GM Cooper ASM Press 4. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2			1			1					1
CO2	2						1	1				1
CO3	1	2	2			2						1
CO4	1	2	2	1		2						1

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC431	UNIT OPERATIONS OF CHEMICAL ENGINEERING I	PCR	3	1	0	4	4
Mathematics, Unit Operations		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	● CA1:To Understand fundamentals of fluid dynamics and mechanics ● CA2:Understanding the fundamentals of heat transfer operations ● CA3:To learn design of heat transfer equipment and calculations ● CA4:To develop knowledge of different mechanical operations and their applications ● CA5:To solve related problems of different difficulty levels through tutorials
Topics Covered	**Module - I** (14 hrs) Fundamental Concepts: Definition of Fluid, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; flow visualization – streamline, path line, streak line, viscosity; Newtonian fluid; Non-Newtonian fluid; Reynold's number—its significance, laminar, transition and turbulent flows. Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices– manometer, U-tube, inclined tube. Introduction to rotational and irrotational flow. Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor. Fluid moving machines: Introduction; Basic classification of pumps: Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); Peristaltic pump; Pump specification; Basic characteristics curves for centrifugal pumps **Module – II** (14 hrs) Basic modes of heat transfer; Heat transfer by conduction: One dimensional steady state heat conduction, Fourier's Law, Thermal conductivity, Compound resistance in series; Steady state heat transfer analysis through extended surface; Unsteady state heat conduction with and without heat generation, Concept of thermal diffusivity; Concept of heat transfer coefficient in convective-conductive system, Critical thickness of insulation. Heat transfer by convection: Convection heat transfer mechanism; Forced convection in systems of simple geometrics (plate, cylinder etc.), Thermal boundary layer; Co-relation for heat transfer coefficient: internal flow & external flow, Momentum & heat transfer analogies. Evaporation: Classification; Capacity, Steam economy; Boiling point elevation (Duhring rule); Material and energy balance of single effect evaporator; Introduction to multiple effect evaporator: Forward feed, Backward feed, Mixed feed, Parallel feed **Module – III** (12 hrs) Particulate solids: Characterization of solid particles, particle shape, particle size, mixed particle sizes and size analysis, specific surface of mixture, average particle size. Screen analysis: Type of screens, ideal screen, real screen, screen effective ness, differential and cumulative analysis, screen capacity.Screening equipment: stationary screens and grizzlies, gyrating screens, vibrating screens and other industrial screens like trammels etc. Comminution of solids (Size Reduction): Factors affecting commnution,comminution laws: Kick's law, Rittinger's law and Bond's law and theirlimitations. Crushing efficiency & power consumption.
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. A Textbook of Fluid Mechanics And Hydraulic Machines, R.K. Bansal, Laxmi (Publications; Tenth edition, 2018 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. 3. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 4. Mechanical Operations for Chemical Engineers, C.M. Narayanan and B.C. Bhattacharya, KHANNA PUBLISHERS, 1990 <u>Suggested Reference Books:</u> 1. Process Heat Transfer: D. Q. Kern, MGH, 1983

	2. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977 3. Principles of Unit Operations by Alan S Foust, L.A. Wenzel, C.W. Clump, L. Maus, and L.B.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	3	3	3	2	1	1	0	3	3	1	3
CO 2	1	3	3	3	2	1	1	0	3	3	1	3
CO 3	1	3	3	3	2	1	1	0	3	3	1	2
CO 4	3	3	3	3	2	1	1	0	3	3	1	3
CO5	1	2	2	3	2	1	1	0	3	3	1	3

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 402	IMMUNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01		CT+MT+EA					
Course Outcomes	CO1: To understand the role of the components of the immune system and its classification CO2: To understand the role of the immune cells and their immunological response in the context of human diseases including infectious diseases, autoimmunity, and cancer. CO3: To learn the fundamentals and principles of immunological techniques and their application. CO4: To understand methods of generations of Polyclonal and Monoclonal Antibody and the use of custom made genetically engineered antibodies. CO5: To solve problems associated with drugs and their toxic response based on the knowledge of immunological response.						
Topics Covered	**Immunology-** fundamental concepts and anatomy of the immune system Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing (6) **Immune responses generated by B and T lymphocytes** Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; (2) Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily (3) Kinetics of Active and Passive Immunity, Basis of self –non-self discrimination; (4) B cell maturation, activation and differentiation; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses (6) Hypersensitivity, Antibody Dependent Cell Cytotoxicity; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation Hapten-carrier system. Complement						

	system. (4) **Antigen – Antibody Interaction dependent Techniques** Precipitation, Agglutination; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, Immuno-electron microscopy and Immunoflourescence techniques (6) **Clinical Immunology** Preparation and clinical uses of Monoclonal and Polyclonal antibody. (3) Transplantation; Autoimmunity; (5) Vaccination: Principles and development of vaccines against different diseases. (3)
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications. 1999 <u>Suggested Reference Books:</u> 1. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002. 2. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999. 3. Goding, Monoclonal antibodies, Academic Press. 1985.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2	2										
CO3	2	2				2						2
CO4		3	3	2	1	2						3
CO5		3	3	3	1	2						3

<table>
<tr><td colspan="9">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC431</td><td>PROGRAMMING AND DATA STRUCTURE</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Knowledge of Programming Language</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understanding of the fundamental concepts of data, data types and abstract data types.
• CO2: Implementation of different abstract data types using different data structures.
• CO3: Apply different types of data structures to implement different solutions to problems.
• CO4: Analysis of the suitability/compatibility of different data structures based on the types of applications.</td></tr>
</table>

Topics Covered	1) Introduction: Basic terminology, elementary data organization, structure operations, algorithm, complexity and time-space trade-off. [2] 2) Arrays: Array definition, representation and analysis, single and multidimensional arrays, address calculation, application of arrays, character string in c, character string operation, array as parameters, ordered list, sparse matrices and vectors. [4] 3) Stacks: Array representation and implementation of stack, operations on stacks: push AND pop, array representation of stack, linked representation of stack, operations associated with stacks, application of stack: conversion of infix to prefix and postfix expressions, evaluation of postfix expression using stack. [5] 4) Queues: Array and linked representation and implementation of queues, operations on queue: create, add, delete, full and empty, circular queues, d-queues and priority queues. [4] 5) Linked list: Representation and implementation of singly linked lists, two-way header list, traversing and searching of linked list, overflow and underflow, insertion and deletion to/from linked lists, insertion and deletion algorithms, doubly linked list, linked list in array, polynomial representation and addition, generalized linked list, garbage collection and compaction. [7] 6) Trees: Basic terminology, binary trees, binary tree representation, algebraic expressions, complete binary tree, extended binary trees, array and linked representation of binary trees, traversing binary trees, threaded binary trees, traversing threaded binary trees. [7] 7) Searching: Sequential search, binary search. [2] 8) Sorting: Insertion Sort, Selection Sort, Bubble Sort, Radix Sort, Quick Sort, Merge Sort and Heap Sort. [8] 9) Binary Search Trees: Binary Search Tree (BST), Insertion, Deletion and Search Operations in BST. [5] 10) Height Balance Tree: Introduction to Height Balance Tree, Insertion, Deletion and Search Operations in Height Balance Tree. [5] 11) Graphs: Terminology and representations, graphs and multi-graphs, directed graphs, sequential representations of graphs, adjacency matrices, traversal, connected component and spanning trees, minimum cost spanning trees. [7]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Horowitz and Sahani, “Fundamentals of data Structures”, Galgotia Publication Pvt. Ltd., New Delhi. 2. R. Kruse etal, “Data Structures and Program Design in C”, Pearson Education Asia, Delhi-2002 3. A. M. Tanenbaum, “Data Structures using C & C++”, Prentice-Hall of India Pvt. Ltd., New Delhi <u>Suggested Reference Books:</u> 1. Bruno R Preiss, “Data Structures and Algorithms with Object Oriented Design Pattern in C++”, Jhon Wiley & Sons, Inc. 2. 6. Adam Drozdek, “Data Structures and Algorithms in C++”, Thomson Asia Pvt. Ltd.(Singapore)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	0	1	0	0	0	0	1	1	0	3
CO2	2	3	3	1	0	0	0	1	2	2	1	2

CO3	2	3	3	3	1	1	0	1	2	2	2	3
CO4	3	3	3	3	2	2	2	2	3	3	3	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS451	CELL BIOLOGY AND GENETICS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Cell Biology and Genetics (BTC301)		CT+EA					
Course Outcomes	CO1: To design, analyze and solve problems related to cell biology and Molecular genetics and interpretation of data obtained by the lab experiments. CO2: To develop skills to perform experiments related to cell biology and Molecular genetics and have hands on training on the related area. CO3: To learn to interpret data, draw conclusion and develop trouble shooting skills.						
Topics Covered	1. Isolation of chromosomal DNA from mammalian cells. 2. Genotyping PCR of a genetically modified cell. 3. Isolation of mRNA and RT-PCR to determine the level of transcription of the gene. 4. Studying to detect variations like single nucleotide polymorphism. 5. Studying bacterial conjugation. 6. To examine the morphology of cells 7. Identification of cellular organelles by staining method 8. Cell proliferation assay 9. Cell adhesion assay 10. Cell migration assay						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: • Molecular Biology of Cell by Albert et.al. John Wiley & Sons • The Cell by Cooper. ASM Press • M.W.Strickberger: Genetics, Pearson.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	2	2	2	1	3
CO2	3	2	2	3	3	3	1	2	3	1	1	3
CO3	3	3	2	2	2	3	1	3	2	3	1	3

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS481	UNIT OPERATIONS OF CHEMICAL ENGINEERING LABORATORY I	PCR	0	0	3	3	3
CHC431: Unit operations of chemical engineering-I.		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To record observations systematically and arrive at required results based on experiments conducted CO2. Understand the principles, laws and mechanism of different comminuting methods like sieve analysis crushers, and grinders, ball mill CO3. Acquire the knowledge of a cyclone separator and its efficiency CO4. Acquire the knowledge of different flow regime measuring instruments. CO5. Study and design different flow measuring instruments.
Topics Covered	• To find out the reduction ratio and capacity and to verify the laws of crushing by Jaw Crusher. • To determine the optimum speed for maximum new surface area created for the given feed size and also determines the critical speed of the ball mill. • Demonstration of the operation of a cyclone separator and determination of its overall efficiency • Experiments on Reynolds Apparatus for determination of flow regime and construction of Fanning friction factor vs. Reynolds No. plot • Determination of co efficient of Discharge for Orifice meter and Discharge for Venturi meter. • Determination of co-efficient of Pitot tube and construction of velocity profile across the cross section of pipe. • Experiment to prove Bernoulli's equation for fluid flow • To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions and to find out screen efficiency
Text Books, and/or reference material	Suggested Text Books: 1. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. Suggested Reference Books: 1. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977 2. Principles of Unit Operations by Alan S Foust, L.A. Wenzel, C.W. Clump, L. Maus, and L.B.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	3	3		1		3	1	3	2
CO 2	3	3	3	3	3		2		3	1	3	2
CO 3	3	3	3	3	3		2		3	1	3	2
CO 4	3	3	3	3	3	1	2		3	1	3	2
CO 5	3	3	3	3	3	1	2		3	1	3	2

<table>
<tr><td colspan="9">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS481</td><td>PROGRAMMING AND DATA STRUCTURE LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Knowledge of Programming Language</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
● CO1: Choose appropriate data structures for representation and manipulation of the data for the given problems.
● CO2: Handle operations like search, insertion, deletion, traversing and sorting on various data structures.
● CO3: Have knowledge on the applications of linear and non-linear data structures for real life problems.
● CO4: Able to store and manipulate data in an efficient manner.
● CO5: Able to implement stack, queue, binary tree, etc. using arrays and linked lists.
● CO6: Able to apply the concepts learnt through thiscourse in various domains like DBMS and compiler.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
Linked List
● Implementations of Linked Lists menu driven program
● Implementation of different operations on linked list – copy, concatenate, split, reverse,
count no. of nodes etc.
● Representation of Sparse matrix using multilinked structure. Implementation of sparse
matrix addition and multiplication
● Implementation of polynomial operations (addition, subtraction) using Linked List
● Implementations of Doubly Linked List
Stack
● Implementations of stack menu driven program using array and linked list
● Implementation of multi-stack in one array
● Implementations of Infix to Postfix Transformation and its evaluation program
● Implementations of Infix to Prefix Transformation and its evaluation program
Queue
● Implementations of double ended queue menu driven program using array and linked list
● Implementations of circular queue menu driven program using array and linked list
● Implementation of Priority queue program using array
Tree
● Implementations of Binary Tree menu driven program
● Implementation of Binary Tree Traversal program
● Implementations of BST program
● Implementation of various operations on tree like – copying tree, mirroring a tree, counting the number of nodes in the tree, counting only leaf nodes in the tree
Sorting
</td></tr>
</table>

	• Implementations Insertion sort, Selection sort, Bubble sort and Quick sort menu driven program **Searching** 12) Implementations of Sequential and Binary Search menu driven program
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Horowitz and Sahani, "Fundamentals of data Structures", Galgotia Publication Pvt. Ltd., New Delhi. 2. R. Kruse etal, "Data Structures and Program Design in C", Pearson Education Asia, Delhi-2002 3. A. M. Tanenbaum, "Data Structures using C & C++", Prentice-Hall of India Pvt. Ltd., New Delhi <u>Suggested Reference Books:</u> 1. Bruno R Preiss, "Data Structures and Algorithms with Object Oriented Design Pattern in C++", Jhon Wiley & Sons, Inc. 2. Adam Drozdek, "Data Structures and Algorithms in C++", Thomson Asia Pvt. Ltd.(Singapore)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	0	0	0	1	1	0	3	3
CO2	3	2	3	0	1	0	0	0	0	0	3	3
CO3	3	1	3	0	0	0	0	0	1	0	3	2
CO4	3	3	2	2	0	0	0	0	1	0	3	3
CO5	2	2	2	1	1	0	0	0	0	0	2	2
CO6	3	3	2	2	2	0	0	0	1	0	3	3

FIFTH SEMESTER

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 501	BIOCHEMICAL REACTION ENGINEERING AND BIOREACTOR DESIGN	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
None	CT+MT+EA
Course Outcomes	CO1 – To gain knowledge about Chemical and Biochemical processes, order of reactions, effect of various parameters on rate constant of a reaction C02- To study about different reactions in batch reactors, kinetics of enzyme catalyzed reactions CO3- To acquire knowledge about different ideal and non-ideal reactors, reaction kinetics, microbial growth kinetics CO4- To learn about various types of Bioreactors, their design considerations and applications in the field of Biochemical Engineering CO5- To study about mass transfer in bioprocess systems, scale up, instrumentation and control, bioreactor considerations in plant and animal cell culture
Topics Covered	Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrhenius equation, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction. [5] Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes.–derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive. [5] Fundamentals of homogeneous reactions for batch, plug flow and mixed flow reactors. [5] Concept of ideal and non ideal reactors, Residence time distribution, Models for non ideal reactors (Dispersion model, tanks-in-series model). [5] Stoichiometry of cellular reactions. Microbial growth kinetics (Batch, continuous, fed batch). Monod model and other kinetic models. Growth kinetics with plasmid instability. [6] Bioreactor design: Packed bed bioreactor, Fluidized bed bioreactor, Bubble column bioreactor, Air lift bioreactor, Tower bioreactor. Hollow fiber bioreactor, Membrane bioreactor. [4] Design of fermenter. Fermenter utilities – boiler and refrigeration system. [5] Immobilized cell bioreactor system. Mass transfer in bioprocess system. Two film theory, K_{la} determination. Scale up concepts. Bioreactor considerations for plant and animal cell culture [5] Bioprocess instrumentation and control. Computer controlled bioreactors.

	[2]
Text Books, and/or reference material	Suggested text books: 1. Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. 2. Bioprocess Engineering Principles – Pauline M Doran. Academic press 3. Chemical Reaction Engineering ,O Levenspiel, Wiley 4. Principles of Fermentation Technology, Stanbury and Whitaker, Pergamon press Suggested reference books: 1. Biochemical Engineering. Fundamentals, Bailey &Olis, McGraw-Hill 2. Biochemical Engineering, Humphrey and Aiba. Academic Press

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	1	1	1	1	1		2
CO2	3	2	2	1	1	1	1	1	1	1		2
CO3	3	2	2	1	1	1	1	1	1	1		2
CO4	3	2	2	1	1	1	1	1	1	1		2
CO5	3	2	2	1	1	1	1	1	1	1		2

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC502</td><td>CELL AND TISSUE CULTURE</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC01 Life Science
BTC301 Cell Biology and Genetics</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will acquire knowledge on plant and animal cell and tissue growth conditions.
CO2: Students will be acquainted with plant and animal cell and tissue culture techniques in laboratory and industry setups.
CO3: Students will be proficient in applying basic understanding of plant and animal cell and tissue growth requirements in plant and animal tissue culture techniques.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introductory history, plant & animal cell culture facilities laboratory organization, media & aseptic conditions. [2]
2. Plant growth hormones, Cell culture, cellular totipotency, somatic embryogenesis, anther, pollen and ovary cultures, protoplast culture. [6]
3. Haploid production, triploid production, in vitro pollination and fertilization, zygotic embryo culture, somatic hybridization and cybridization, genetic transformation, somaclonal and gametoclonal variant selection. [7]
4. Production of disease-free plants, clonal propagation. [3]
5. Industrial applications: secondary metabolite production, germplasm conservation.</td></tr>
</table>

	[3] 6. Animal Cell Culture: Historical Background. [1] 7. Importance of and progress in Animal Cell Culture Technology. [1] 8. Biology of Animal Cell; Cellular Interactions. [5] 9. Importance of Serum and Serum Free Media. [2] 10. Culturing and Sub-Culturing of Animal Cells. [3] 11. In Vitro Transformation of Animal Cells. [1] 12. Cell Differentiation & Cell Movement. [2] 13. Cloning of Animal Cells. [2] 14. Cell Line Preservation. [1] 15. Cell Line Characterization. [2] 16. Chromosome Spreading and Karyotype Analysis. [2] 17. Mycoplasma: Detection and Control. [1] 18. Monoclonal Antibody Production. [2] 19. Insect Cell Culture: An Overview. [2]
Text Books, and/or reference material	Suggested Text Books: 1. Razdan – Introduction to Plant Tissue Culture, 2nd edition, 2007, Oxford and IBH Publishing. 2. "Culture of AnimalCells: A manual of basic technique", 4 th Edition Author(s)/Editor(s): Freshney RI. Publisher: WIELY-LISS ISBN:0-471-34889-9. Suggested Reference Books: 1. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice, a revised edition, 2009, Elsevier. 2. Jha and Ghosh – Plant Tissue Culture: Basic and Applied, revised 2nd edition, 2016, Platinum Publishers.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2			1		1	1	1				1
CO2	2			1		1	1	1				1
CO3	1	2	1									1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC503	BIOSEPARATION AND BIOCHEMICAL ANALYSIS	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic Physics, Mathematics including basics of Differential & Integral Calculus, Basic concepts of Chemistry & Biochemistry	CT+MT+EA

Course Outcomes	CO1: To learn the concepts of separation including purification sequence and its monitoring and the properties of proteins underlying bioseparations.

	CO2: To learn techniques of biochemical analysis of biomolecules. CO3: To learn and analyze, mathematically wherever applicable, the various unit operations in bioseparation. CO4: To understand the design aspects of unit operations in bioseparation. CO5: To solve problems of bioseparations including industrial bioseparations.
Topics Covered	**Basic Concepts** **[3]** Basic concepts of Bio-separation Technology **Basic Analytical Tehniques:** **[10]** Introduction to Biomolecules, Buffers Estimation of carbohydrate, protein, and lipid, and enzyme assay Quantitation of DNA and RNA Methods of cell disintegration **Removal of Insolubles** **[9]** Flocculation and conditioning of broth. Filtration at constant pressure and at constant rate; equations for batch and continuous filtration, centrifugal and cross-flow filtration. Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications. **Techniques Involved in Separation Processes for Solutes** **[9]** Foam-fractionation; Solvent extraction, aqueous two-phase extraction, adsorption & desorption processes; Salt precipitation Membrane based separation processes:Micro-filtration, Dialysis, Reverse osmosis, Ultrafiltration and affinity ultrafiltration, concentration polarization, rejection, flux expression, membrane modules, dead-end and cross-flow modes. **Advanced Techniques for Bioseparation:** **[9]** Chromatography: paper chromatography, TLC, gel filtration, ion exchange, hydrophobic interaction chromatography, affinity chromatography, HPLC. Electrophoresis: Theory and application of Polyacrylamide and Agarose gel electrophoresis; 2D-Gel electrophoresis **Industrial Application with an example** **[2]**
Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Suggested Reference Books: 1. D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 2. Shuler & Kargi, Bio-process Engg. PHI 3. Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO 4	PO5	PO6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12
CO 1	1	1	-	-	-	1	1	1	-	2	-	-
CO 2	1	2	-	2	1	1	-	1	1	2	-	1
CO 3	2	3	1	-	-	-	-	-	1	2	-	-
CO 4	1	-	2	-	1	-	1	-	2	2	1	-
CO 5	3	2	3	1	-	1	1	1	2	2	1	2

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC531	UNIT OPERATIONS OF CHEMICAL ENGINEERING-II	PCR	3	1	0	4	4
CHC431: Unit operations of chemical engineering-I.		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• To learn different types of mass transfer phenomena • Understanding the fundamentals of mass transfer operations • To learn design parameters, their effects and calculations • To compare different types of mass transfer operations and their applications • To solve related problems of different difficulty levels through tutorials
Topics Covered	**Module I:** Principles of mass transfer: Introduction, diffusion, classification of diffusion, Inter-phase mass transfer. [8 hr] **Module II:** Evaporation: Introduction, types of evaporators, design calculation and processes [8 hr] **Module III:** Drying: Principles of drying, drying characteristics, methods, equipment. Humidification and Dehumidification: Definitions, adiabatic saturation temperature, wet bulb temperature, processes [8 hr] **Module IV:** Absorption: Principle, operation and design calculation [8 hr] **Module V:** Distillation: Flash distillation, differential distillation, fractionation and design calculations [8 hr] **Module VI:** Extraction and Adsorption: Principles and Operations. [8 hr]
Text Books, and/or reference material	Suggested Text Books: 1. B.K.Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Private Limited 2. N Anantharaman and K.M.M.S. Begum, Mass Transfer theory and practice. Prentice Hall India Private Limited 3. Robert E. Treybal, Mass Transfer Operations, McGraw Hill limited Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO 12
CO 1	1	3	3	3	2	1	1	0	3	3	1	3
CO 2	1	3	3	3	2	1	1	0	3	3	1	3
CO 3	1	3	3	3	2	1	1	0	3	3	1	2
CO 4	3	3	3	3	2	1	1	0	3	3	1	3
CO5	1	2	2	3	2	1	1	0	3	3	1	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO540	MINERAL BIOTECHNOLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA
Course Outcomes	• CO1: To understand the nature and characteristics of different biogeochemical cycles and involvement important micro-organisms. • CO2: To learn the basic concepts of bioleaching and biobeneficiationalong with the microbiological aspects • CO3: To gain the detail knowledge bioleaching processes with examples. • CO4: To demonstrate and provide examples on how to use microbes for the environmental pollution control
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8
Text Books, and/or reference material	Suggested Text Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology , Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235 , 1983 Suggested Reference Books: 1. Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	2	1	1	-	1	-	-	1
CO2	2	1	1	-	1	-	2	1	1	1	-	1
CO3	2	1	1	1	1	-	1	-	1	-	-	1

CO4	2	1	1	1	1	-	2	1	1	1	1	1

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO541	INTRODUCTION TO COMPUTATIONAL BIOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Life Science BTC01		CT+MT+EA					
Course Outcomes	● CO1: To impart knowledge of life science and biologicaldata ● CO2: To acquire knowledge of computational and mathematical skills for addressing important biologicalquestions. ● CO3: To learn how to develop and implement computational algorithms and tools for processing biologicaldata						
Topics Covered	1. Introduction to Computational biology and its applications(2) 2. Central dogma and biological macromolecules- DNA, RNA & proteins(2) 3. Major biological databases related to DNA, RNA, proteins &metabolic pathways(3) 4. Basic file formats & sequence representation(2) 5. Computational algorithms for Sequence Alignment: Local and global alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7) 6. Algorithms for phylogenetics: Tree constructions(5) 7. StructuralBioinformatics: A. Protein Structure and itsvisualization(2) B. Protein structural alignment(3) C. Protein secondary Structure Prediction(4) D. Protein tertiary Structure Prediction(4) E. RNA Structure Prediction(3) F. Molecular docking and docking algorithms(3) 7. Application of machine learning in biological sciences (Basic concepts) (2)						
Text Books, and/or reference material	Suggested Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor LaboratoryPress 2. Introduction to Bioinformatics by Arthur MLesk Suggested Reference Books: 1. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R.Taylor. 2. Essentials of Bioinformatics by JinXiong						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1			1	1			1			

CO2	3	3	2		2	1			2			
CO3	3	3	2	2	3	1		1	3	1	2	1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 551	IMMUNOLOGY LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA					
		CT+EA					
Course Outcomes	CO1: To learn the fundamentals of immunological techniques CO2: To be able to perform techniques routinely used in immunology, particularly the use of specific antibody in biomolecular applications. CO2: To be able to isolate, count and identify different types of blood cells. CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results. CO5: To understand the basic hazards of working with human samples and antigens and safety measures to be taken						
Topics Covered	1. Cell count with Haemocytometer 2. Determination of viability of the cells 3. Serology: Preparation of the blood smear 4. Blood cell identification 5. Blood grouping by Agglutination assay 6. Quantitative WIDAL test (By tube test and slide test) 7. Precipitation test: Immunodiffusion 8. Enzyme linked Immunosorbent Assay (ELISA) 9. Protein detection by Western blot technique. 10. Lymphocytes isolation using FicollHypaque technique						
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Immunology Laboratory manual. 2. ArtiNigam,ArchanaAyyagari,"Lab Manual in Biochemistry, Immunology and Biotechnology",McGraw Hill Education, India, 2007 <u>Suggested Reference Books:</u>						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2			2		1						2
CO2	2		2	1					1			2
CO3	2	1	1	2					1			1
CO4		1								3		2
CO5						2		2				2

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS-552	BIOPROCESS TECHNOLOGY LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+ EA					
Course Outcomes	CO1: To learn about surface culture fermentation in lab scale CO2: To learn about submerged culture fermentation in lab scale and various assays for antibiotics production, polysaccharide production and cell growth determination CO3: To learn about cell immobilization by entrapment method						
Topics Covered	1. Production of neomycin by fermentation 2. Production of citric acid by fermentation 3. Production of xanthan/dextran gum by fermentation 4. Production of Bakers yeast by fermentation 5. Cell Immobilization by entrapment method						
Text Books, and/or reference material	Suggested Text Books: 1. Experimental Process Biotechnology Protocols, S N Mukhopadhyay, Viva Books, 2007. Suggested Reference Books:						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1			1		1	2	3	2		2
CO2	1	1			1		1	2	3	2		2
CO3	1	1			1		1	2	3	2		2

<table>
<tr><td colspan="8">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>CHS581</td><td>UNIT OPERATIONS OF CHEMICAL ENGINEERING LABORATORY II</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Unit operation of Chemical Engineering I and II</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Apply the knowledge of fundamentals of heat and mass transfer equipment on laboratory
• CO2: Experimentation and data analysis
• CO3: Handling various instruments and solve various difficulty levels
• CO4: Learn industrial applications of heat transfer equipment
• CO5: Complete process design through assignment / group task</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Determination of thermal conductivity of metal rod
• Determination of overall heat transfer coefficient in a counter-current & parallel flow double pipe heat exchanger.
• Determination of overall heat transfer coefficient in a shell and tube heat exchanger.
• Experimental test rig on drop-wise and film-wise condensation for assessing the performance.
• Studies on estimation of hold-up volume under steady state condition and evaluate the overall performance of a rotary dryer.
• Determination of overall efficiency of cooling tower
• Estimation of rate of drying of specific biomass under steady state condition in a atmospheric tray dryer
• Performance studies on continuous fractionating distillation column in terms of distillate, bottom product and reflux quantities, % loss, % recovery, energy consumption etc. 36 hr</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1) Transport Processes and Unit Operations - C. J. Geankoplis
2) Heat Transfer: Principles and Applications: B. K Dutta
<u>Suggested Reference Books:</u></td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	3	3		1		3	1	3	2
CO 2	3	3	3	3	3		2		3	1	3	2
CO 3	3	3	3	3	3		2		3	1	3	2
CO 4	3	3	3	3	3	1	2		3	1	3	2
CO 5	3	3	3	3	3	1	2		3	1	3	2

SIXTH SEMESTER

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	ECONOMICS AND MANAGEMENT ACCOUNTANCY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• To review basic economic principles with students; • To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works; • To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.
Topics Covered	PART 1: Economics Group A: Microeconomics Unit 1: Economics: Basic Concepts Unit 2: Theory of Consumer Behaviour Unit 3: Theory of Production, Cost and Firms Unit 4: Analyses of Market Structures: Perfect Competition Unit 5: Monopoly Market Unit 6: General Equilibrium &Welfare Economics Group B: Macroeconomics Sl. No. Name Unit 1: Introduction to Macroeconomic Theory Unit 2: National Income Accounting Unit 3: Determination of Equilibrium Level of Income Unit 4: Money, Interest and Income Unit 5: Inflation and Unemployment Unit 6: Output, Price and Employment PART 2: Accountancy Sl. No. Name Unit 1: Introduction to Accounting Unit 2: Primary Books of Accounts (Journal) Unit 3: Secondary Books of Accounts (Ledger) Unit 4: Cash Book Unit 5: Bank Reconciliation Statement Unit 6: Trial Balance Unit 7: Final Accounts

Text Books, and/or reference material	Suggested Text Books: PART 1: Economics Group A: Microeconomics 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics Group B: Microeconomics 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. SoumyenSikder: Principles of Macroeconomics PART 2: Accountancy 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	1	-	-	3	-	-	3	2	1	-
CO2	3	2	-	1	-	2	-	2	-	-	3	1
CO3	-	-	-	-	1	-	3	-	-	-	2	-

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC601	BIOINFORMATICS	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Cell Biology and Genetics (BTC301), Biochemistry and Enzyme Technology (BTC303), Programming and Data Structure (CSC431)		CT+MT+EA					
Course Outcomes	• CO1: To learn how to integrate both biological and computer skills for addressing important biological questions. • CO2: To acquire knowledge of existing biological databases and understand the methods for storing, organizing, retrieving and analyzing biological data in an efficient way. • CO3: To learn and implement computational algorithms and tools (webservers and standalone programs) for processing biological data						
Topics Covered	1. Introduction to Bioinformatics and its applications (2) 2. Linux and Bash programming for bioinformatics (3) 3. Major Information Resources & biological databases (3)						

	4. Sequence Alignment: Sequence similarity, Sequence identity, Sequence homology, Gap Penalty, local and global alignment, pairwise and multiple alignments, sequence alignment algorithm, Dynamic programming, BLAST and PSI-BLAST, Application of BLAST tool, Concept of Scoring matrix (5) 5. Molecular phylogeny and evolution: Phylogenetics basics and methods for phylogenetic tree constructions (4) 6. Structural Bioinformatics: A. Protein Structure and its visualization, structural alignment (3), B. Protein secondary Structure Prediction (2), C. Protein tertiary Structure Prediction (2), D. RNA Structure Prediction (2) 7. Molecular Docking and Drug design (Basic concepts) (2)
Text Books, and/or reference material	Suggested Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. Introduction to Bioinformatics by Arthur M Lesk Suggested Reference Books: 1. Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck 2. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R. Taylor. 3. Essentials of Bioinformatics by Jin Xiong

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	1	1	1							3
CO 2	3	2	1	1	1							3
CO 3	3	3	2	2	2	2			1		1	3

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC631	DATABASE MANAGEMENT SYSTEM	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: Understand the basic concepts and appreciate the applications of database systems CO2. Comprehend the fundamentals of design principles for logical design of relational databases CO3: Apply the query writing skill CO4. Discuss the basic issues of transaction processing and concurrency control						
Topics Covered	1. Introduction of DBMS. 5L 2. Concept of E-R diagram, Extended E-R diagram. 5L 3. Relational Algebra 4L 4. Queries with various operations 4L						

	5. SQL Queries 4L 6. Index structure design 5L 7. Normalization (Different normal forms) 5L 8. Basic concepts on transaction processing 5L 9. Various concurrency-control protocols (2 phase locking, time stamp protocol) 5
Text Books, and/or reference material	Suggested Text Books: 1. Silberschatz, H. F. Korth and S. Sudharshan, "Database System Concepts", Sixth Edition, Tata McGraw Hill, 2011. 2. R. Elmasri, S. B. Navathe, "Fundamentals of DBMS Systems", Pearson education. Sixth Edition. 3. Kahate, "Introduction to Database Management Systems", Pearson Education, New Delhi, 2006. Suggested Reference Books: 1. C.J.Date, A.Kannan and S.Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
CO1	3	1	0	0	0	3	1	3	0	1	2	3
CO2	3	3	3	2	0	2	2	1	3	2	2	3
CO3	3	2	3	0	3	2	2	1	3	2	2	3
CO4	3	1	1	0	0	1	1	1	1	2	1	3

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC631	Process Control & Instrumentation	PCR	2	1	0	3	3
Mathematics, Unit Operations		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Analyze open-loop system • CO2: Analyze and apply the knowledge of linear closed-loop systems. • CO3: Develop working knowledge of control system by frequency response • CO4: Analyze the response of instruments and ability to integrate knowledge about instrument • CO5:Explain the importance and application of instruments						
Topics Covered	Laplace Transform, 1st order response, 1st order in series, linearization, 2nd order Dynamics (12) Feedback control system, Servo and regulator problem, Transfer function of Controller, Final control element, Control valve characteristics, Transportation Lag, Routh-Hurwitz Criteria and stability (12) frequency response of closed-loop, frequency response technique, Bode Diagram and stability criteria (8) Static and dynamic responses, Measurement of temperature and pressure (5)						

	instruments for process plant to measure flow, level and concentration of fluid (5)
Text Books, and/or reference material	Suggested Text books: 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. Chemical Process control, G. Stephanopoulos, PHI, 2008 3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996) 4. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000) Suggested Reference Books: 1. Jone's Instrumentation Technology (all the volumes) 2. Instrumentation and Devices by Rangan& Sharma 3. Considine's Handbook on Instrumentation 4. Atomic absorption and Emission Spectrophotometers, Ed Metcalfe 5. Industrial Instrumentation, D.P.Eckman

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3		3			1	3	1	2	3
CO2	3	3	3		3			1	3	1	2	3
CO3	3	3	3		3			1	2	1	2	3
CO4	2	2	3	2	3			1	2	1	3	3
CO5	2	2	3	2	3			1	3	1	3	3

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE610</td><td>Animal Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To elucidate the scope of Animal Biotechnology.
CO2: To learn the different areas of Animal Biotechnology applications.
CO3: To learn the basic technology in each area of Animal Biotechnology.
CO4: To learn the future prospect of the Animal Biotechnology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Animl Cell culture:History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions. Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization (8)
Technology – Present and future :
Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering (4).
In Vitro Fertilization and Embryo Transfer:
Basic knowledge on Fertilization and embryology, Steps involved in IVF, Fertilization by</td></tr>
</table>

	means of micro insemination, PZD, ICSI, SUZI, MESA (4) **Stem cells:** Classification and types, Sources, Markers, Differentiation signals, application, IPSC, Cncer stem cells (4). **Gene Therapy:** Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system, Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vector system, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents (4) **Transgenic and Konck out Animals:** Methodology, Embryonic Stem Cell method, Microinjectionmethod, Retroviral vector method, Applications of transgenic animals **Recombinanat protein expression and purification:** Expression vectors for mammalian proteins, Cell (S cerevicea, P pasturis etc.) for large scale mammalian protein production, Post translational modification and purification.
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Animal Cell Culture by John R.W. Masters; Oxford University Press <u>Suggested Reference Books:</u> 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts; Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. & Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1			1		1				2
CO2			1			1		1				3
CO3						2	1	2				2
CO4								1	1	1		2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE611	Industrial Microbiology	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To interpretbasic concepts for the production of microbial products.fermentation and separation technology CO2: To learn about the different types of Bioreators and their use.						

	CO3: To analyse the principles, and techniques for improving the yield and desired properties in via strain improvement strategies. CO4: They will be able to apply the knowledge related to processes, equipment for industrial purpose and solve the problems.
Topics Covered	<u>**Industrial Microbiology– BTE611**</u> **Introduction to Fermentation Technology: 12** Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. Types of Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; Media sterilization,.Preparation of microbial inoculum for Industrial fermentations. **Commercial strain development: 12** Induced mutations, Over producing decontrolled mutants, Catabolic derepressed mutants; Genetically engineered strain; Protoplast fusion technique. Improvement of strain by Site directed mutagenesis and Protein engineering : Definition, methods and application. Improving microbial strain forproduction of Amino acids Lysine and nucleosides and nucleotidesforaroma.Methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. **Microbial processes for production of valuables 10** Introduction, on Microbial growth and its kinetics.Primary and secondary metabolites and their regulation. Microbial production of organic acids, antibiotics,alcohol, bakers yeast, Single cell protein (SCP); Vitamins.Organisms used,(wild and mutated). production method-process, recovery of products separation parameters , purification steps..Application . **Microbial Enzyme Technology: 10** Microbial process for production of enzymes.Commercial production of enzymes; amylases, proteases,cellulase.Enzyme Modification - site directedmutagenesis;Importance of Stability of enzymes;Enzyme stabilization by selection and protein engineering for T4 Lysozyme; Principles & techniques of immobilization of Enzymes, Application of immobilized enzyme in Industrial processes
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Industrial Microbiology, Casida L E 2. Biotechnology: A textbook of industrial microbiology: CruegerW ,Crueger A 3. Industrial Microbiology, Prescott & Dunn <u>Suggested Reference Books:</u> 1. Prescott's and Dunn's, A. Industrial Microbiology, 4th edition. CBS Publishers, New Dehli , India , 1987. 2. L.E. Cassida.Jr, Industrial Microbiology, New Age International Publisher 3. Atkinson.B and Marituna.F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ. Ltd. 4. Bailey &Olis, Biochemical Engineering Fundamentals, MGH. 5. Review papers from reputed international journals to convey the current progress .in this area.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1						1					1
CO2	1	2										
CO3	1			2								1
CO4			2			1	1					1

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE612</td><td colspan="2">NUTRACEUTICAL AND NUTRIGENOMICS</td><td>PER</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: To establish the correlation between nutraceuticals with cell signaling pathway.
CO2: To target nutraceuticals from different sources for prevention of disease.
CO3: To understand the interaction between gut microbiota with functional food components and nutraceuticals and improvement of health.
CO4: To formulate the concept of nutrient gene interaction for prevention of lifestyle related disorders.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals. [8]
Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics and transcription factors. [8]
Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds. [5]
Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria [7]
Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in Nutrigenomics [12]</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput, Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John Shi , CRC Press
2. Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press
<u>Suggested Reference Books:</u>
1. Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press
2. Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade
3. Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Haslr, Blackwell Publishing Professional</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	2	1	1	1	1
CO2	3	3	3	3	3	3	3	3	1	1	1	3

CO3	3	3	3	3	3	3	3	1	1	1	1	3
CO4	3	3	2	3	3	3	3	1	1	1	1	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE613	Human Genomics	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Cell Biology and Genetics (BTC301), Biochemistry and Enzyme Technology (BTC303), Molecular Biology and rDNA Technology (BTC401)	CT+MT+EA

Course Outcomes	• CO1: To understand the general organization of human nuclear and mitochondrial genome and know about the salient features and characteristics. • CO2: To acquire knowledge the human genome project and its implication on clinical biology in the post genomic era. • CO3: To familiarize with different scientific techniques used for studying different features of genome. • CO4: To get an overview about different applications of the genomic based knowledge .
Topics Covered	1. Patterns of genome organization (10) 2. Structural genomics (2) 3. Functional genomics (2) 4. Reverse genetics (2) 5. Gene patenting (2) 6. Electronic PCR (2) 7. Genome mapping and genome sequencing (2) 8. Specialized database in molecular biology (2) 9. Human genome project progress (2) 10. Genes in health and disease(2) 11. Genomic disorders and molecular medicine (2) 12. Minimal cell Genome (2) 13. Prospects of Gene therapy in Human (2) 14. Pharmacogenomics (2) 15. Genebank (2) 16. Legal status of gene bank (2)
Text Books, and/or reference material	Suggested Text Books: 1. T. A. Brown, Genomes, John Wiley & Sons Suggested Reference Books: 1. Singer.M, and Berg.P, Genes and genomes, Blackwell Scientific Publication, Oxford , 1991 2. Beebe.T, and Burke.T, Gene Structure and Transcription, 2nd edition,1992, Oxford Univ Press 3. Glick and Pasteurneck, Molecular Biotechnology, Principles and Applications of Recombinant DNA technology, ASM Press 4. Strachan & Reed, Human Molecular Genetics, Garland Science. 5. Cantor & Smith, Genomics, John Wiley & Son

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	2	1	1	3	1	2	1	2	1	3
CO 2	3	2	3	2	2	3	1	2	1	2	1	2
CO 3	3	3	3	3	3	3	1	2	1	2	1	3
CO 4	2	2	2	2	3	3	1	3	1	2	1	3

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE614	MOLECULAR VIROLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Cell Biology (BTC 301/BT 403), Molecular Biology (BTC 401/ BT 404), and Immunology (BTC 402/ BT 501)	CT+MT+EA

Course Outcomes	• CO1: Acquire an understanding of virus life cycle and host-virus interactions. • CO2: Acquire an idea about detection, prevention and treatment of virus infections. • CO3: To learn about use of virus in biotechnology.
Topics Covered	Brief history and principles of virology. (1) Principles of virus classification. (2) General structure of viruses; Viroids, Virusoids, Satellite viruses, and Prions. (2) Genome of plant and animal viruses. Mobile genetic elements. (4) Replications of RNA viruses. (5) Replication of DNA viruses. (5) Virus-cell interactions: cytopathology; virus entry and egress; host cell shut off and IRES;viral persistence and latency. (6) Methods to diagnose virus infections. (3) Antiviral vaccines. (3) Antivirals: interferons and its mechanisms of action. (2) Gene silencing. (2) Culture and purification of viruses. (2) Viral vectors and gene therapy. (2) New and emerging viruses (3)
Text Books, and/or reference material	Suggested Text Books: 1. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. Suggested Reference Books: 1. Fields Virology by Lippincott Williams and Wilkins.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2						1					1
CO2	2	1		1			1					1

CO3	2	1	2			2		1				1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 615	BIOMETTALURGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Microbiology, Chemical Kinetics	CT+MT+EA

Course Outcomes	**CO1:** To recapitulate the basics of bioenergetics and to understand the relevant biogeochemistry & microbiology. **CO 2:** To learn about the concepts of bioleaching and biobeneficiation along with the microbiological aspects **CO 3:** To learn about bioleaching processes with typical examples. **CO 4:** To analyze the kinetics of bioleaching **CO 5:** To understand the enzymatic mechanism of bioleaching.
Topics Covered	Recapitulation of basics of bioenergetics (ATP as an energy-rich molecule, oxidation-reduction reactions), Biogeochemical cycles – sulphur, iron, and manganese cycles. Nature and characteristics of biogeochemically important micro-organisms. (9) Bioleaching: definition, scope, advantages & disadvantages; Types: direct, indirect, & indirect contact. Types of bioleaching with respect to reaction intermediates (thiosulphate& polysulphide mechanisms). Autotrophs & heterotrophs as candidate microorganisms for bioleaching. Bioleaching by aerobic and anaerobic microorganisms. (9) Bioleaching processes: in situ, heap & dump, & reactor bioleaching. Bioleaching of copper by *Acidithiobacillus* from chalcopyrites, chalcocite, &covellite. Dump & heap and reactor bioleaching of copper. Uranium bioleaching &biobeneficiation of gold. Environmental pollution control in gold recovery processes. (9) Kinetics of pyrite bioleaching – two-subprocess mechanism- ferric leach kinetics & kinetics of bacterial oxidation of ferrous iron. Modelling of continuous tank bioleaching of pyrite – unsegregated and segregated models. (9) Oxidation of iron by Acidithiobacillus – enzymatic mechanism; role of cytochromes &rusticyanin, elements of electron transport pathways in iron & sulphur oxidation. (6)
Text Books, and/or reference material	Suggested Text Books: **1.** Pillai Abhilash, B. D. Pandey, K. A. Natarajan. Microbiology for Minerals, Metals, Materials and the Environment, CRC Press, 2018 **2.** Ross W. Smith &ManoranjanMisra, ed. Mineral Bioprocessing, The Minerals, Metals & Materials Society, 1991 Suggested Reference Books: 1. L. M. Prescott, J.P.Harley, D.A.Klein. Microbiology 5thedn. Mc-Graw Hill, 2002. 2. M.E. Curtin, Microbial mining and metal recovery biotechnology (1), pp 229-235, 1983 3. Woods D, Rawling D.E., Bacterial bleaching and biomining in marx J.L. (ed), Revolution in biotechnology, Cambridge University Press

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12

COs												
CO1	-	-	-	1	-	-	2	-	-	2	-	1
CO2	1	-	-	1	-	1-	3	1	-	2	-	-
CO3	1	1	2	1	-	1	3	1	-	2	1	1
CO4	2	3	1	1	1	-	-	-	-	1	-	1
CO5	1	2	1	3	-	-	-	-	-	2	-	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE616	NANOBIOTECHNOLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC01 (Life Science), PHC01 (Physics), CYC01 (Chemistry)	CT+MT+EA

Course Outcomes	• CO1: Acquire an idea about nanoscale phenomenon • CO2: To learn about the basic investigation tools for the nanobiotechnology • CO3: To learn about bottom up and top down synthesis of nanosystems • CO4: to get comprehensive understanding of applications of nanotechnology in biology
Topics Covered	• Nanotechnology; introduction to miniaturization. (4) • Iinvestigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. Investigation tools: lithography (8) • Nanomaterials: organic and inorganic nanoparticles. Synthesis, assembly, and processing of nanostructures: phenomenon of self-assembly. (6) • Molecular self-assembly and bottom up synthesis of nanomaterials. (6) • Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6) • Nanofiber-based scaffolds and tissue engineering; nanodiagnostics & biosensing. (6) • Nanotoxicology. (4) • Future Concepts in Nanobiotechnology. (2)
Text Books, and/or reference material	Suggested Text Books: 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. Suggested Reference Books : 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge Univ. Press

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	1	1	1	1	0	0	0	1	0	2
CO 2	3	3	2	3	3	1	0	0	0	1	0	2

CO 3	3	3	2	3	3	1	0	1	0	1	0	2
CO 4	3	3	2	3	3	3	1	1	0	1	0	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 617	MARINE BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To learn about the bioprocess engineering aspects of marine products in commercial production CO2: To learn about the industrial applications of various marine products and their production CO3: To study the specific applications in energy, pharmaceutical and environmental sector.		
Topics Covered	**Bioprocess engineering of marine products**	Marine microbiology	3
		Photobioreactors – light regime	
		mass transfer and scale up, downstream processing of marine products	6
		Management of Marine production, Storage and transport.	4
		Marine natural products, valuable chemicals, bioactive compounds from micro-algae	4
	Specialized aspects	Cultivation of marine microorganism	3
		marine biomedical and bioactive compounds from marine organisms	3
		commercial bio-products from marine organisms	2
		biohydrogen production in photobioreactor, marine enzymes	3
		Marine bio-film and bio-remediation	3
		marine bio-sensor and transgenic marine organisms	2
		Marine Pharmacology: Potentialities in the Treatment of Infectious Diseases, Osteoporosis and Alzheimer´s Disease	3
		Molecular biodiversity	2
		marine products as biomarkers	2
		Economic and Regulatory Aspects of Marine Biotechnology	2
Text Books, and/or reference material	<u>Suggested Text Books:</u> <u>Suggested Reference Books:</u> 1. Marine Bioprocess Engineering, J.G. Burgess R. Osinga R.H. Wijffels, Elsevier, 1999 2. Handbook of Marine Biotechnology, **Kim**Se-Kwon , Springer, 2015		

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1		1		1	1	1		2
CO2	1	1	1	1		1	1	1	1	2		2
CO3	1	1	1	1		1	3	1	1	2		2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 618	FOLDING, MISFOLDING AND DISEASES	PEL	3	0	0	3	3
BTC401- Molecular biology &rDNA Technology; BTC 303 Biochemistry & Enzyme Technology; BTC 301 Cell biology and genetics			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
		CT+MT+EA					
Course Outcomes	• CO1: To acquire an understanding of the protein structure • CO2: To learn about the principles of protein folding and misfolding • CO3: To obtain a comprehensive idea of different diseases related to protein misfolding • CO4: Development of cumulative understanding of protein folding, misfolding and diseases to find much-needed cure for the relevant conditions.						
Topics Covered	Basic of protein misfolding related diseases. The hierarchical structure of the protein. Principles of protein stability and folding. (16) Protein misfolding and aggregation. Protein quality control: molecular chaperones, protein degradation, autophagy and aging. (12) Prion Diseases. Alzheimer's Disease. Parkinson's Disease. Huntington's Disease and other unstable repeat disorders. Amyotrophic lateral sclerosis and frontotemporal lobar degeneration. (14)						
Text Books, and/or reference material	Suggested Text Books: 1. Fundamentals of Neurodegeneration and Protein Misfolding Disorders by Martin Beckerman, Springer 2. Introduction to Protein Structure by Carl IV Branden, Routledge Suggested Reference Books: 1. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding by Alan Fersht, W. H. Freeman.						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

COs \ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	3	3	3	2	1	1	0	3	3	1	3
CO 2	1	3	3	3	2	1	1	0	3	3	1	3
CO 3	1	3	3	3	2	1	1	0	3	3	1	2
CO 4	3	3	3	3	2	1	1	0	3	3	1	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE619	ENGINEERING RESISTANCE IN	PEL	3	0	0	3	3

	PLANTS						

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC502 (Cell & Tissue Culture of Animals & Plants)	CT+MT+EA
Course Outcomes	CO1: To develop the basic knowledge for genetic improvement of crop plants. CO2: Understanding the sources of useful genes required for engineering resistance. CO3: Learning of fundamentals of gene mapping and gene isolation. CO4: Learning the basics and methods of genetic transformation of plants. CO5: Solving problems related to biotic and abiotic stress faced by crop plants.
Topics Covered	**Introduction:** Principles of gene manipulation in plants and basic concepts of genetic improvement of crop plants**[5]** **Molecular markers & Cloning genes:**Identifying the good gene sources, general strategies for cloning genes from plants, Cloning methods based on DNA insertions, subtractive cloning, map-based cloning, chromosome walking, chromosome jumping, morphological markers, biochemical markers, molecular markers – RFLP, RAPD, AFLP, ISSR, RAMP, STMs, fingerprinting, SNPs**[10]** **Genetic Engineering:**Agrobacterium-plant interaction; virulence; Ti and Riplasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid;Genetic transformation Agrobacterium-mediated gene delivery; cointegrateandbinary vectors and their utility; direct gene transfer - PEG-mediated,electroporation, particle bombardment and alternative methods; screenableandselectable markers; characterization of transgenics; chloroplast transformation **[10]** **Applications:**Genetic engineering of resistance to biotic stress, tolerance to abiotic stress, removal of environmental pollutants, quality nutrition and health, molecular farming **[10]** **Biosafety concerns:**Removal of selectable markers from GM crops,Modern tools of genetic manipulation of plants; genome editing **[7]**
Text Books, and/or reference material	Suggested Text Books: 1. H.S.Chawla, Introduction to Plant Biotechnology, Oxford & IBH Publishing co. Pvt..Ltd 2. Slater.A.,NigelW.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press. 3. Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. 4. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub. Suggested Reference Book: 1. Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. 2. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. 3. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice 1996 Elsevier

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	0	0	1	0	0	2	0	1	0	0	2
CO2	1	0	0	2	0	0	2	0	2	0	0	1
CO3	1	0	0	2	2	3	2	2	2	0	0	1
CO4	3	0	0	2	2	2	2	3	3	0	0	3
CO5	3	2	3	2	2	2	3	3	2	0	0	3

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS651</td><td>MOLECULAR BIOLOGY AND rDNA TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the principle of isolation of nucleic acids through different techniques.
CO2: To understand the techniques used in manipulation of nucleic acids.
CO3: To develop expertise to apply the toolsof gene cloning and solve the problems associated with production of recombinant protein from genetically modified microorganisms.
CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results
CO5: To understand the basic hazards of working with nucleic acids and safety measures.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Isolation of genomic DNA
2. Quantification of DNA
3. Agarose Gel Electrophoresis of DNA
4. Isolation of RNA
5. Agarose Gel Electrophoresis of RNA
6. Isolation of plasmid – agarose gel electrophoresis (quantitation and purity test)
7. Restriction digestion of plasmid – agarose gel electrophoresis
8. Bacterial transformation using plasmid having antibiotic resistant marker and some other genetic markers.
9. Southern Blotting
10. PCR technique</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested text Books:</u>
<u>Suggetsed Reference Books:</u>
Sambrook et al., “Molecular Cloning” A Laboratory Manual</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2			2					2		1	2
CO2			1	2					2		1	2
CO3		2	2	2					2		1	2
CO4		1								3		2
CO5						2		2				2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS652	BIOINFORMATICS LABORATORY	PCR	0	0	3	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Programming and Data Structure (CSC431)		CT+EA					

Course Outcomes	• CO1: To acquire programming knowledge to analyze biological data • CO2: To learn about different biological databases and retrieval of biological data in different file formats. • CO3: To learn different bioinformatics softwares related to sequence, structure and phylogeny
Topics Covered	1. Bash programming (Linux commands) for data mining (3) 2. Handling Biological databases and sequence and structure retrieval (2) 3. Pairwise Sequence Alignment: BLAST tool and interpreting the results (1) 4. Multiple Sequence Alignment: Clustal, Muscle etc. (1) 5. Phylogenetics methods for phylogenetic tree constructions: Mega, Phylip (1) 6. C and Python scripts to analyse and interpret biological data (3) 7. Protein Structure and its visualization, structural alignment softwares: PyMOL, Rasmol, VMD (1) 8. Protein Structure prediction softwares: Modeller, I-Tasser, Psipred (1) 9. RNA related softwares: Vienna Package (1)
Text Books, and/or reference material	Suggested Text Books: 1. The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr. 2. Python Crash Course by Eric Matthews Suggested Reference Books: 1. A Byte of Python by C.H. Swaroop 2. A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	1	3	3	2						3
CO 2	3	2	1	3	2	3						3
CO 3	3	2	2	3	3	3			3	1	2	3

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS681	DATABASE MANAGEMENT	PCR		0	3	3	1.5

	SYSTEM LABORATORY						

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
1. Computer fundamentals, Data structures 2. Fundamentals of any computer programming languages	CT+EA

Course Outcomes	CO1: Understand, appreciate and effectively explain the underlying concepts of database technologies CO2. Design and implement a database schema for a given problem CO3. Populate and query a database using SQL DML/DDL commands
Topics Covered	1. SQL Queries 2. PL/SQL assignments
Text Books, and/or reference material	Suggested Text Books: SQL and PL/SQL by Evan Bayross. Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	3	3		3	2	1	2	0	1	2	2	3
CO2.	3	3		3	1	1	2	0	2	2	2	2
CO3.	3	3		3	2	1	2	0	2	2	2	2

SEVENTH SEMESTER

Department of Management Studies								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1:To make budding engineers aware of various management functions required for any organization • CO2:To impart knowledge on various tools and techniques applied by the executives of an organization • CO3:To make potential engineers aware of managerial function so that it would help for their professional career • CO4:To impart knowledge on organizational activities operational and strategic both in nature • C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science						
Topics Covered	**UNIT I:** Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter's five forces, Management functions – overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization**(8)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7) **UNIT III:** Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8) **UNIT V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)						
Text Books, and/or reference material	Suggested Text Books: 1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. 2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education 4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 5. Operations Management, 7th edition (Quality control, Forecasting), Buffa&Sarin, Willey Suggested Reference Books:						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1									3	2	2	
CO2				2					2	2		
CO3				2					3	2		
CO4							1		3			
CO5				2					2	2	2	

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
BTE710	MOLECULAR PLANT PATHOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE), mid-term (MT) and end assessment (EA))					
BTC01		CE+MT+EA					
Course Outcomes	CO1: To understand molecular mechanisms of plant defense systems. CO2: To understand molecular mechanisms of pathogenesis. CO3: To have the idea to design strategies for protection of plants.						
Topics Covered	Introduction to molecular plant pathology [1] Plant diseases [2] Plant disease development and environment [2] Effects of pathogen on plant physiology [2] Biochemistry of plant defense reactions [5] Plant-pathogen interactions [5] Genetic regulation of resistance in host plants [5] Genetic regulation of virulence in pathogen [5] Mechanisms of host defense [5] Mechanisms of pathogenesis [5] Biotechnological approach for plant protection; genetically modified plants to protect against pathogens [5]						
Text Books, and/or reference material	Suggested Text Books: 1. Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. 2. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. Suggested Reference Books: 1. Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. 2. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer 3. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1	2	1	2	1	2	1	1			1
CO2		1	1	1	2		1	1				1
CO3	1	1	2	2	2	2	1	1	2	1		1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 711	CANCER BIOLOGY AND CELL SIGNALING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC301-Cell Biology and Genetics/BT-817- Cancer Biology		CT+MT+EA					
Course Outcomes	• CO1: To understand the basic concepts of cancer biology and related cellular signaling • CO2: To understand the development and causes of cancer. • CO3: To understand the therapeutic aspects of cancer prevention • CO4: To identify the target molecules that are associated with cancer so that the cancer preventive small molecule inhibitors/phytochemicals can be screened.						
Topics Covered	**Cancer Biology** Introduction to Cancer and Molecular basis of cancer [2] Mutation and DNA damage repair mechanism [2] Cell cycle [3] Oncogenes (tumor viruses) , Tumor suppressors [3] Epigenetics, non-coding RNAs and genome fluidity in cancer [4] Cancer and Stem Cells, Angiogenesis, Apoptosis [4] Cancer therapy, Future of Cancer research [3] **Cell Signaling related to cancer** Introduction to cellular signaling [3] Signaling molecules – (e.g. Hormones, Interferons and others) [3] Receptor-mediated signaling in cells [3] Role of different transcription factors and kinases (e.g. MAP kinases and other ser/thr kinases) [4] Involvement of different signal transduction pathways during cancer initiation, progression and metastasis [5] Small molecule inhibitors of cancer [3]						
Text Books, and/or reference material	Suggested Text Books: 1. Weinberg RA. The Biology of Cancer, 2nd Edition. Garland Science, 2013. 2. Cellular signal processing , 2nd Edition by Friedrich Marks, Ursula Klingmuller and Karin Muller-Decker, Garland Science Suggested ReferenceBooks: Selected reviews and primary scientific literature						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	-	2	2	-	1	-	-	1	2	1	2
CO 2	1	1	2	2	1	1	1	1	2	2	1	2
CO 3	1	1	1	2	1	-	1	-	1	2	1	2
CO 4	1	1	2	2	1	2	3	-	1	1	1	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE712	FOOD BIOTECHNOLOGY	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation and increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.
Topics Covered	**Food for health and wellness** **[2]** **Food Microbiology:** **[6]** Detection of microorganism in food – role of PCR, DNA CHIP, rapid methods for identification of microorganism in food, immunological methods, Bioassay, Biosensors-detection of toxin, heavy metal , pesticide and herbicides **Food preservation** **[10]** Pasteurization, sterilization, Canning, Irradiation, Dehydration, low temperature Food preservation, use of preservatives, **Food fermentation** **[8]** Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages , dairy product, non beverage product , use of genetic engineering techniques for improved quality product. **Genetically modified food** **[6]** Fruit ripening, improvement of sweetness, flavor, starch, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Single cell protein, single cell oil, Spirulina, **Biotechnology in relation to food product and Food Safety** **(5+5)** Antioxidant, nutraceutical, Nutrigenomics Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series
Text Books, and/or reference material	Suggested Text Books: Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Suggested Reference Books: Fundamentals of Food Biotechnology by Lee

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	2	1	1	2	3
CO2	3	3	3	3	2	2	3	2	1	1	2	3

CO3	3	3	3	3	3	3	3	3	2	1	2	3
CO4	3	2	3	3	1	3	3	2	2	1	1	3
CO5	3	2	2	2	3	3	3	3	3	3	3	3

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE713	BIOPHARMACEUTICAL PROCESS DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To learn about the manufacturing process and facility design for biopharmaceutical products CO2: To acquire knowledge of detailed design of GMP compliant biopharma plant CO3: To study the design and optimization of downstream processes of therapeutic protein manufacture in a commercial set up CO4: To learn about technology transfer, regulation, validation and quality assurance of biopharma industry						
Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6] Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [12] Role of process development group and manufacturing group in biopharmaceutical process start up. [3] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [5] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [6]							

Text Books, and/or reference material	Suggested Text Books: 1. Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press 2. Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH Suggested Reference Books: 1. Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare 2. Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	1	1	2	1	1	1	1	2
CO2	2	2	3	1	1	1	2	1	1	1	1	2
CO3	2	2	2	1	1	1	1	1	1	1	1	2
CO4	2	2	2	1	1	1	2	2	1	1	3	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE714	BIOENERGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	1. Learn about energy crisis, problems of fossil fuel use, global warming 2. Learn about production of biological solid fuel. 3. Learn about gaseous biofuel production like methane and hydrogen in detail. 4. Learn about liquid biofuels 5. Learn about benefits and deficiencies of biofuels, life cycle analysis						
Topics Covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6] Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel. Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5]						

	The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6] Jatropha cultivation, National hydrogen energy road map. [3]
Text Books, and/or reference material	Suggested Text Books. 1. Biofuels production, application and development. Alan Scragg, CABI. Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1				2	3	1	1	1		2
CO2	2	2	2			2	3	1	1	1		2
CO3	2	2	2			2	3	1	1	1		2
CO4	2	2	2			2	3	1	1	1		2
CO5	1	1				2	3	1	1	1		2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE715	PROJECT ENGINEERING FOR BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To learn about detailed design of a manufacturing plant CO2: To learn about cleaning, sterilization, waste management and utilities of a biotechnology production plant CO3: To study about Planning, construction and commissioning of a biopharmaceutical manufacturing plant CO4: To learn about project management and financial aspects of the plant
Topics Covered	Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments& their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods [6] Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and cleanability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. [6] Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) [6] Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. [6]

	Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. [6] Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. [6] Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. [3] Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. [3]
Text Books, and/or reference material	Suggested Text Books: 1. Bioprocess engineering: system, equipment and facilities, B K Lydersen, NAD'Elia, K M Nelson. Wiley 2. Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley Suggested Reference Books: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	2	1	1	1	1	2
CO2	3	3	3	2	1	1	3	1	1	1	1	2
CO3	3	3	3	2	1	1	2	1	1	1	1	2
CO4	3	3	3	2	1	1	2	1	1	1	3	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 716	STRUCTURAL BIOLOGY	PEL	3	0	0	3	3
BTC401- Molecular biology &rDNA Technology and BT C303 Biochemistry & Enzyme Technology		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: To acquire understanding of the basic building blocks of life • CO2: To learn about the most common structural motifs found in protein and DNA • CO3: To understand the atomic level interaction between the protein and DNA • CO4: To learn how to determine protein structure						
Topics Covered	Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, folding and flexibility, DNA structures. (8) Structure, function and engineering - DNA recognition in prokaryotes by helix-turn-helix motifs. (4) DNA recognition by eukaryotic transcription factors, specific transcription factors (5)						

	Enzyme catalysis with example of serine proteinases, membrane proteins, signal transduction, fibrous proteins (7) Recognition of foreign molecules by immune system, structure of spherical viruses (8) Prediction, engineering and design of protein structures, determination of protein structures (10)
Text Books, and/or reference material	Suggested Text Books: 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge Suggested Reference Books: **1.** Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	3	3	3	0	1	1	0	1	2	0	1
CO 2	1	3	3	3	0	1	1	0	1	2	0	1
CO 3	1	3	3	3	0	1	1	0	1	2	0	1
CO 4	3	3	3	3	3	0	0	0	1	2	0	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE717	ENVIRONMENTAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To learn about air pollution monitoring and control CO2: To learn about waste water treatment processes along with analytical procedures CO3: To study about solid waste management CO4: To acquire knowledge on bioremediation of pollutants						
Topics Covered	Air pollution control methods and equipment - Primary and secondary air pollutants, Effect of air pollutants on health, Control of gaseous and particulate pollutants, air pollution control equipments. 6 Water pollution: sampling and analysis - Sampling, BOD and COD analysis, Bacteriological measurements, Numerical problems 5 Water and waste water treatment processes - Overview of treatment principles. Primary treatment – screening, sedimentation, flotation, neutralization etc. 4 Secondary treatment - Activated sludge process, extended aeration, Trickling filter, Aerated lagoons, Waste stabilization ponds, Aquatic plant systems, UASB reactors. Design of a complete mix activated sludge process. 8 Biomethanation. Nitrification and denitrification operations. Phosphorus removal. Sludge treatment and disposal. Tertiary treatment. Membrane based treatment processes. 8 Solid waste management, Vermiculture, hazardous waste management 5 Specialized aspects - Bioremediation for recovery of metals, Xenobiotics, Degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, Phytoremediation. Reactors in						

	bioremediation. 6
Text Books, and/or reference material	<u>Suggested Text Books</u>: 1. Introduction to waste water treatment processes, Ramalho, Elsevier. 2. Environmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. &Greogia; PHI 3. Waste water treatment and disposal, Arceivala, Wiley 4. Environmental Biotechnology, Alan Scragg, Oxford University press <u>Suggested Reference Books</u>: 1. Waste water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill 2. Industrial Water Pollution Control, Eckenfelder, McGraw Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	1	3	1	1	1		2
CO2	3	2	2	1	1	1	3	1	1	1		2
CO3	3	2	2	1	1	1	3	1	1	1		2
CO4	3	2	2	1	1	1	3	1	1	1		2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE718	PROTEOMICS AND PROTEIN ENGINEERING	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC303 Biochemistry and Enzyme Technology; BTC401 Molecular Biology and Recombinant DNA Technology;	CT+MT+EA
Course Outcomes	**CO1:**Students will acquire knowledge on protein structure and function and will be able to apply the understanding in designing strategies for proteomic analysis and protein engineering. **CO2:**Students will be acquainted with tools and techniques for proteomic analysis and will be able to analyze proteomic data using databases. **CO3:** Students will be acquainted with tools and techniques for protein engineering and will be able to apply them to solve problem related to protein function and efficiency.
Topics Covered	1. **Introduction to proteinstructure and function:** Elementary ideas of bonding and structure, stereochemistry; spectroscopic techniques. Amino acid structure and properties to 3D structure of protein. Basic principles of protein folding anddynamics. Protein sequence andevolution. [10] 2. **Proteomics and its application:** Chromatography principles. Analytical protein and peptide Separation, Protein Digestion Techniques, Mass Spectrometers for protein and peptide analysis, protein identification by peptide Mass fingerprinting. Mining proteomes, protein expression profiling, identifying protein-protein interactions and protein complexes, Mapping protein modifications. [16]

	3. **Protein Engineering:** Proteins design and engineering, Random, site directed mutagenesis; Strategies to alter catalytic efficiency; structure prediction and odelling proteins; Molecular graphics in protein engineering; Dynamics and mechanics; Drug-protein interactions and Design; applications of engineered proteins. [16]
Text Books, and/or reference material	Suggested Text Books: 1. R.M. Twyman; Principles of Proteomics, Bioscientific Publishers. 2. Biotechnology, 2nd Edition 2015. David Clark and Nanette Pazdernik. Academic Cell. Suggested Reference Books: 1. B.Alberts,D.Bray, J.Lewis et al, Molecular Biology of the Cell, Garland Pub. N.Y 1983. 2. Richard J. Simpson, Proteins and Proteomics, I.K. International Pvt Ltd. 3. Daniel C. Liebler, Introduction to Proteomics: Tools for the New Biology, Humana Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2											1
CO 2	2	2	2	1	1	1						1
CO 3	2	2	2	1	1	1	1					1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE719	MOLECULAR MODELLING &DRUG DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Biochemistry and Enzyme Technology, Bioinformatics		CT+MT+EA					
Course Outcomes	• CO1: To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. • CO2: To learn the fundamental concepts of structure-activity relationships • CO3: To learn design of novel, biologically active compounds and Toelucidate the mechanism of action of drugs						
Topics Covered	2. Introduction to molecular Simulation Techniques (5) 3. Quantum chemistry for Modeling of small molecules (5) 4. Molecular Dynamics Methods- Molecular Dynamics of rigid non linear poly atomic molecules in ensembles, Structural information from M.D. (5) 5. Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable forcefields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) 6. Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design:						

	Principles of receptor based de novo ligand design. Rigid body molecular Docking. (7)
Text Books, and/or reference material	Suggested Text Books: **1.** A R Leach-Molecular Modelling,. Principles and application 2nd edition–Prentice Hall. **2.** Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London Suggested Reference Books: 1. G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley 2. Scolnick.J.(2001) Drug Discovery and Design .Academic Press, London N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design.* Academic Press, San Diego, 1996.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2										2
CO 2	3	2	2		2							2
CO 3	3	3	3	2	3	1	1	1	1			3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE720	NANOTHERAPEUTICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1:To understand the role of the small molecules in the drug delivery system. CO2: To learn the fundamentals and principles of nanotechnologies in drug release system. CO3: To understand methods of nanotechnology in point of care diagnosis. CO4: To understand the basic mechanism of nanotherapeutics of tumours.						
Topics Covered	**UNIT -I NANOPHARMACEUTICALS** **Nano-biotechnology for Drug Discovery** -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules . 5 Dendrimers, Nanobodies, Nanospheres-Nanotubes –Nano-cochleates.-Nano-molecular Valves for Controlled Drug Release –Nano-motors for Drug Delivery. 6 **UNIT - II ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES** **Development of nano medicines** – Nano Shells – Nano pores – Tectodendrimers – Nanoparticle drug system. Biomedical nanoparticles –Liposome's Different types of drug loading – Drug release – Biodegradable polymers. 5 Applications Nano biotechnologies for Single-Molecule Detection -Protease-Activated Quantum Dot Probes. 3 Nanotechnology for Point-of-Care Diagnostics –Nano diagnostics for the Battle Field – Nano diagnostics for Integrating Diagnostics with Therapeutics. 4						

	UNIT – III APPLICATION IN CANCER THERAPY & NANOMEDICINE **Introduction and Rationale for Nanotechnology in Cancer Therapy** -- Diagnostic approach by nano-sensing. 3 Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications. 5 Pharmacokinetics of Nano-carrier-Mediated Drug and Gene Delivery. 4
Text Books, and/or reference material	Suggested Text Books: 1. Kewal K. Jain, The Handbook of Nano-medicine Humana Press, (2008). Suggested Reference Books**:** 1. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005). 2. Robert A. Freitas Jr., —Nano-medicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3	3	3	1	1	2	0	1	2	2
CO2	2	3	3	3	2	3	3	2	1	1	1	2
CO3	3	3	3	3	3	1	2	2	2	1	2	1
CO4	1	2	3	2	3	1	1	3	1	1	1	3

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE721</td><td>BIOMATERIALS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">BT C303 Biochemistry & Enzyme Technology, CYC01 Chemistry</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Classify the biomaterials and recognize their production and properties.
• CO2: Explain the application areas of biomaterials
• CO3: To realize the important basic properties and requirements for biomaterials
• CO4: Recognize the importance of relationships between living tissues and biomaterials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Definition of biomaterials – biologically derived materials or materials compatible with biology. (2)
• Common biomaterials: some proteins, many carbohydrates and some specialized polymers. (4)
• Collagen (protein in bone and connective tissues): Structure production and its use. (3)
• Fibroin (protein in silk): Production and its use. (2)
• Production of these proteins by conventional cloning methods. (3)
• Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; (8)
• Biopolymers: Synthesis from a simple biological monomer (eghyaluronate polymers); Dextrans (used in chromatography columns); Rubberllike materials produced by bacteria</td></tr>
</table>

	and fungi (Polyhydroxybutyrate PHB), Polycaprolactone(PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligeneseutrophus; Biodegradable polymers **(8)** ● Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. **(8)** ● Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems. **(4)**
Text Books, and/or reference material	Suggested Text Books: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Suggested Reference book: 1. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	2	2	1	3	1		3	3	3
CO 2	3	3	3	2	2	1	3	1		3	3	3
CO 3	3	3	3	3	2	1	3	1		3	3	3
CO 4	3	3	3	2	3	1	3	1	1	3	3	3

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE722</td><td>VACCINE TECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC402 Immunology</td><td colspan="7">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">● CO1: To understand the factors that influence vaccine design and development
● CO2: To understand how research based discovery has driven vaccine development
● CO3: To know about the different types of vaccines
● CO4: To learn about the quality control and regulation in the vaccine production
● CO5: To understand the importance of vaccination as a public health strategy</td></tr>
<tr><td>Topics Covered</td><td colspan="8">History of vaccine development- Importance of vaccines (2)
Immunological response to vaccines (2)
Vaccine design and development: Epitope identification; Vaccine efficacy, Adjuvants (6)
Different types of vaccines: Inactivated toxins, Inactivated whole bacteria or viruses, Live attenuated bacteria or viruses; Subunit vaccines, Polysaccharide vaccines, Conjugated vaccines ; Recombinant DNA vaccines, Edible vaccines, Virus like particles(8)
Next-generation vaccines: Human Immunome project; Human antibodies as vaccines (4)
Production techniques used for vaccines (4)
Storage and preservation of vaccines (4)</td></tr>
</table>

	Delivery methods: microspheres, nanoparticles; ISCOMS and immunomodulators (6) Regulatory issues in vaccine production: OIE guidelines for production and seed lot management; Manufacturing recommendation; Final product release tests (5) Vaccine safety-the debate (1)
Text Books, and/or reference material	Suggested Text Books: 1. New Vaccine Technologies: Ronald W. Ellis (Landes Bioscience), 2001. 2. Vaccines: Stanley A. Plotkin, Walter A. Orenstein, Paul A. Offit(Elsevier), 6^{th} Edition Suggested Reference Books: 1. Medical Microbiology : Samuel Baron , 4^{th} Edition (University of Texas) 2. Advances in Vaccine Technology and Delivery: Cheryl Barton, Espicom Business Intelligence. 3. "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries": Noel Mowat ,Daya books.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2				1							1
CO2	2	3		2								1
CO3			2			2	1					2
CO4			2			2	2	1			1	2
CO5							1			2		2

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE723</td><td>STEM CELL BIOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Cell Biology, Biochemistry, Genetics, Molecular Biology</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signalling molecules and the use of such factors for tissue production in-vitro.
• CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodelling to correct these changes
• CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy.
• CO4: To understand the recent advances on application the regenerative therapy from well characterzied case studies.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. An Introduction to Stem Cells (2)
2. Adult Stem Cells (1)
3. Embryonic Stem Cells (1)
4. Induced Pluripotent Stem Cells (1)
5. Hematopoietic Stem Cells (1)
6. Messenchymal stem cells , cord blood cells, Lessons from Medipost company</td></tr>
</table>

<table>
<tr><td></td><td>products like Neurostem, Cardiostem, Cartistem, Pneumostem (4)
7. Molecular and Cellular Bases of Organ Development (6)
8. Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals (4)
9. Molecular Bases of degenerative disease (1)
10. Therapeutic Uses of Stem Cells with examples (2)
11. In vivo Regeneration of Tissues by Cell Transplantation (2)
12. IPS Cells as Experimental Models of Neurodegenrative Disorders: use of them as disease modelling platform, novel drug testing and tissue renerarative therapy and implantation studies(2)
13. Studies of Patients Treated with Stem Cells, The modalities of treatment, Preperation of cells/tissues/scaffolds and Trnasplantation procedure (3)
14. Tissue Regeneration Driven by Growth Hormones (2)
15. Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs (8)
16. Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td>Suggested Text Books:
4. Stem Cells, Tissue Engineering And Regenerative Medicine By: David Warburton 1st Edition.
5. Principles of Regenerative Medicine by Anthony Atala Robert Lanza Tony Mikos Robert Nerem , 3rd Edition.
6. Translational Regenerative Medicine by Anthony Atala and Julie G. Allickson
Suggested Reference Books:
1. The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G. Tenth edition.
2. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, IstEdtion.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	1	1	3	1	1	2	-	-	2	-	1
CO 2	2	1	2	3	2	2	2	-	-	2	-	-
CO 3	2	2	3	2	3	3	3	-	3	2	-	2
CO 4	3	2	3	3	2	2	3	-	3	2	-	2

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE724</td><td>APPLICATIONS OF MOLECULAR CLONING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC401 (Molecular Biology &rDNA Technology)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To understand the fundamentals of molecular cloning.
CO2: To learn the basic methods of molecular cloning.
CO3:To gain knowledge about the potential application aspects of molecular cloning.
CO4: To build-up a bridging concept for extension of theoretical knowledge to practical applications of molecular cloning.</td></tr>
</table>

Topics Covered	**Module 1: Basic principles of molecular cloning** - Why gene cloning and DNA analysis are important (2) - Vectors for gene cloning (2) - Purification of DNA from living cells (2) - Manipulation of purified DNA (3) - Introduction of DNA into living cells (3) - Cloning vectors for prokaryotes (3) - Cloning vectors for eukaryotes (3) - How to obtain a clone of a specific gene (2) - Other molecular techniques (2) **Module 2: Applications of molecular cloning in research** - Sequencing genes & genomes (3) - Studying gene expression & function (3) - Studying genomes (4) **Module 3: Applications of molecular cloning in biotechnology** - Production of protein from cloned genes (2) - Gene cloning & DNA analysis in medicine (3) - Gene cloning & DNA analysis in agriculture (3) - Gene cloning & DNA analysis in forensic science &environment (2)
Text Books, and/or reference material	Suggested Text Books: 1. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Seventh Edition, Wiley Blackwell. Suggested Reference Books: 1. Sandy B. Primrose, Richard Twyman& Bob Old, Principles of gene manipulation primrose: An introduction to genetic engineering, Sixth Edition, Blackwell Science

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	0	0	2	0	0	2	0	2	0	0	1
CO2	2	0	0	2	0	0	2	0	2	0	0	1
CO3	2	2	3	0	3	3	2	2	2	0	0	2
CO4	3	3	2	0	2	2	3	2	2	0	0	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	GENETIC ENGINEERING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	**CO1:**Students will acquire basic understanding of molecules of life and their basic chemistry. **CO2:**Students will acquire knowledge of how genetic material stores programs of life and how that information is retrieved. **CO3:** Students will acquire knowledge of basic tools of genetic engineering and their applications. **CO4:**Students will be able to apply the acquired knowledgein understanding and solving biotechnology issues surrounding us.						

Topics Covered	1. Structures of macromolecules such as Carbohydrates, Proteins, Enzymes, Lipids and Nucleic Acids. [10] 2. Basics of cell biology, prokaryotes vs. eukaryotes, sub-cellular structures, their organization and functions. [10] 3. Central Dogma of molecular biology, DNA Replication, Transcription, Reverse Transcription, Translation. [10] 4. Basic tools of nucleic acid manipulation. Methods of genetic engineering; Genetic engineering of microbes, plants and animals.[12]
Text Books, and/or reference material	Suggested Text Books: 1. Essential Cell Biology, 4th Edition, Albertset. al. 2. Biotechnology.2nd Edition, 2015. David Clark and Nanette Pazdernik.Academic Cell. 3. Cecie Starr, Christine A. Evers, Lisa Starr. Biology: Today and tomorrow with physiology. Suggested Reference Books: 1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, Molecular Biology of the Cell, Garland Science. 2. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											1
CO2	2											1
CO3	2						2	2				1
CO4		1	1			2						1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS751	BIOSEPARATION AND BIOCHEMICAL ANALYSIS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous assessment (CA), mid-term (MT) and end-term examination (ET))					
Bioseparation& Biochemical Analysis (BTC 503)		CA+ET					

Course Outcomes	**CO1:** To determine the specific cake resistance & filter medium resistance by constant pressure filtration/pressure-time variation in constant rate filtration **CO2:** To prepare a cell-free extract by sonication/homogenization and identify a specific protein therein by Western Analysis **CO3:** To learn the technique of salt precipitation of a protein and subsequent dialysis for removal of the salt and to get an idea of other equipment for concentrating a protein **CO4:**To construct a binodial diagram and study the extraction of a protein in an aqueous two-phase system **CO5:**To separate out a protein from a mixture by gel filtration/ion exchange chromatography and to concentrate a protein by ultrafiltration **CO6:** To extract and estimate biomolecules such as lipids, DNA, & RNA

Topics Covered	1. Filtration (constant pressure filtration) 2. Preparation of cell-free extracts from cultured cells 3. Salt precipitation of protein and Dialysis 4. Extraction and estimation of total lipid content 5. Separation/concentration of proteins by Ultrafiltration. 6. Aqueous two phase extraction (binodial diagram) 7. Separation of proteins by gel permeation/ion-exchange chromatography 8. Identification of a specific protein present in the cell-free extract by Western Analysis 9. Determination of DNA and RNA concentration by UV absorption 10. Demonstration of lyophilization& Rotary vacuum evaporation
Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry Principles and techniques (5thed)/ Principles and Techniques of Biochemistry and Molecular Biology (7thed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Suggested Reference Books: 1. Holme & H. Peck, Analytical Biochemistry, 3rded, Longman, 1998 2. Shuler & Kargi, Bio-process Engg. PHI 3. Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	-	-	-	-	-	-	-	1	2	-	-
CO 2	2	1	-	2	1	1	1	1	2	2	-	1
CO 3	1	-	1	-	1	-	1	-	1	2	1	2
CO 4	1	-	1	-	-	-	-	-	1	2	1	-
CO 5	1	-	2	1	1	-	1	-	2	2	-	1
CO 6	1	-	-	1	1	1	-	1	1	2	-	1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS752	CELL & TISSUE CULTURE LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC01 Life Science BTC301 Cell Biology and Genetics BTC 502 Cell and Tissue Culture	CT+EA
Course Outcomes	CO1: Students will be acquainted with basic plant tissue culture techniques. CO2: Students will be acquainted in basic animal cell culture techniques. CO3: Students will attain knowledge of application of cell and tissue culture techniques in academic and industrial laboratories. CO4: Students will have knowledge of biosafety and ethical issues related to cell and tissue

	culture.
Topics Covered	**Plant Tissue Culture** 1. Preparation and sterilization of plant tissue culture media. 2. Preparation of explants. 3. Callus induction in rice. 4. Regeneration of rice callus tissue. 5. Rooting of regnerants in rice. **Animal Cell Culture** 6. Sterilization Techniques, Preparation of Media & Preparation of Sera 7. Primary Cell Culture 8. Preparation of established Cell lines 9. Cell Counting and Viability 10. Staining of Animal Cells & Preservation of Cells
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: 1. Laboratory manual

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		1	1					1			1
CO2	2		1	1					1			1
CO3	2		1	1						1		1
CO4						2	1	1				1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 753	BIOCHEMICAL REACTION ENGINEERING LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					

Course Outcomes	1. To learn the experimental protocol of microbial growth and inhibition kinetics in a batch process 2. To study substrate degradation, cell growth and product formation with immobilized cells in plug flow bioreactors. 3. To learn about functions of a fermenter 4. To study non-ideality in a plug flow reactor
Topics Covered	1. Microbial cell growth kinetics 2. Microbial cell inhibition kinetics 3. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous packed bed reactor. 4. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous fluidized bed reactor. 5. Function of bioreactor- a) calibration of DO electrode. B) Calibration of pH electrode.

	6. RTD studies in a packed bed reactor
Text Books, and/or reference material	Suggested text Books: Suggested Reference Books: 1. Laboratory manual

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1		2		1	2	3	2		2
CO2	2	1	1		2		1	2	3	2		2
CO3	2	1	1		2		1	2	3	2		2
CO4	2	1	1		2		1	2	3	2		2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 754	VOCATIONAL TRAINING / SUMMER INTERNSHIP AND SEMINAR	PCR	0	0	3	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NA		EA					
Course Outcomes	• CO1: To learn literature mining and acquire knowledge of presenting data in a proper format • CO2: To enhance the communication skills of students • CO3: Enable the students to face various kinds of audiences and develop self-confidence • CO4: To learn application of ethical principles in various fields of research						
Topics Covered	Each student is allotted a slot where he/she presents a scientific topic (related to the summer training they did in the previous semester)						
Text Books, and/or reference material	Suggested Text Books: N.A. Suggested Reference Books:						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2	3	2	2	2	2	1	3	3	3
CO 2	1	2	1	2	2	1	1	1	3	3	3	3
CO 3	1	2	1	2	1	1	1	1	3	3	3	3
CO 4	3	2	3	3	2	3	2	3	3	2	2	3

<table>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PCR)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS755</td><td>PROJECT-I</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">All the Program Core subjects</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works.
CO2: Familiarization with recent researches in the field of biotechnology.
CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area.
CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills.
CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project.
Students are required to familiarize themselves with the literature review and scientific techniques and skills.</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="6"><u>Suggested text Books:</u>
<u>Suggested Reference Books</u>:
• Related research papers.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	2	2	2	3	3	3
CO2	3	2	2	3	2	2	1	1	1	2	3	3
CO3	3	3	3	2	2	2	1	3	3	1	3	3
CO4	3	3	3	2	3	3	2	3	2	2	3	3
CO5	3	3	3	3	3	3	2	3	3	3	3	3

EIGHTH SEMESTER

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE810	PLANT DEVELOPMENTAL BIOLOGY	PCR	3	0	0	3	3
Pre-requisites Plant Molecular Biology and Genetics		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA)					
NIL		CT+MT+EA					

Course Outcomes	CO1: Students will Learn about the roles of light and various phytohormones in plant growth and development. CO2: Students will acquire knowledge about soot and root apical meristems. CO3: Students will Learn about the effect of different environmental factors on plant growth and development. CO4: Students will be able to apply the acquired knowledge in understanding and solving biotechnology issues in a societal context.
Topics Covered	Embryogenesis and Organogenesis (4) Soot and root apical meristem (2) Growth of seedlings (5) Environmental Factor (2) Totipotency (4) Phototropism and gravitropism (3) Plant morphology (2) Photomorphogenesis (6) Phytohormones (4)
Text Books, and/or reference material	Suggested Text Books: 1.Lewin B: Genes (VI and above Edition). 2. Albert, B: Molecular Biology of the Cell (any Edition). Suggested Reference: 1. Research articles will be given by the teacher.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2		2				1				
CO2		1		1						2		
CO3		2		2	1	2	2					1
CO4						1						

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE811</td><td>BIOPROCESS PLANT & EQUIPMENT DESIGN</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
</table>

Course Outcomes	CO1- To understand the basic concepts of site selection and plant location for a Bioprocess Plant. CO2- To understand the design concepts of Bioreactors, both conventional and unconventional. CO3- To study the various equipment used in Bioprocess plant and cost analysis performed in Bioprocess plant for various processes.
Topics Covered	**Plant Location and Site Selection: (5)** ● Site and Plant Layout ● Utilites ● Storage Methods and Material Handling ● Plant operation and Control systems ● Environmental considerations **Conventional and unconventional bioreactors and their Design: (12)** ● Batch, Continuous stirred tank bioreactors (CSTBR) ● Plug flow bioreactors ● Enzyme and immobilized bioreactors ● Fluidized bed bioreactors, ● Bubble column bioreactors and Air- lift bioreactors ● Hollow- fiber bioreactors ● Membrane bioreactors ● Bioreactors for plant and animal cell culture systems ● Ideal and non ideal reactors **Sterilization of Bioreactors: (4)** ● Design of Batch and Continuous Media Sterilizers ● Design of Air Sterilizers. **Instrumentation and Control of Bioprocesses: (4)** ● Physical and chemical environmental sensors ● Computer control of bioreactors **Modelling and Simulation of Bioprocesses: (2)** ● Study of structured and unstructured models for analysis of various processes **Design of Bioreactor systems: (6)** ● Design of Filtration and Centrifugation equipments ● Design of Driers. ● Refrigeration systems ● Steam Generation systems ● Pumps **Cost Analysis in Bioprocess Engineering: (2)** ● Estimation of capital investment and operating cost

Text Books, and/or reference material	Suggested Text Books: 1.Bioprocess Engineering Principles, by Pauline M.Doran Academic Press 2. Bioprocess Engineering ,Kinetics, Biosystems, Sustainability and Reactor Design by Shijie Liu Elsevier 3. Coulson & Richardson's Chemical Engineering Vol.6 Butterworth-Heinemann Suggested Reference Books: 1. Plant design and Economics for chemical engineers by Peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Coulson & Richardson's Chemical Engineering Vol.3 Butterworth-Heinemann

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	2	2	3	3	3	2	3	3	2
CO 2	3	3	3	3	3	2	3	2	3	3	3	3
CO 3	3	3	3	2	2	2	2	2	3	2	2	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE812	MEDICAL & PHARMACEUTICAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	CO1: To give an understanding of various techniques of modern biotechnology in the field of Medical Science. CO2: To provide knowledge about the concept and application of monoclonal antibody technology CO3: To demonstrate and provide examples on how to use microbes and mammalian cells for the production of pharmaceutical products CO4: to explain the general principles of generating transgenic plants, animals and microbes
Topics Covered	**Introduction -** Biopharmaceuticals and their development, historical aspects, general steps in development of a drug, sources and strategies (including random, non-random, and rational) of discovering lead compounds 2 **Drug designing** Macromolecules as Targets of drugs: (lipids, carbohydrates, proteins, nucleic acids) 2 Drug targets: carrier proteins, structural proteins, enzymes, receptors (including mechanisms – ion channels and membrane-bound enzymes) 4 Concepts and design criteria of agonists, antagonists, partial agonists, and inverse agonists. 3 Rational drug designing, Structure –activity relationships and identification of pharmacophore and auxophore in a lead compound; drug design on the basis of drug-target interactions. 5 **Disease diagnosis** PCR, LCR immunological assay, Detection of genetic, Neurogenetic disorders involving Metabolic and Movement disorders. Treatment-products from recombinant and non-

	recombinant organisms, Interferons, Antisense therapy, cell penetrating peptides. Gene therapy, Types of gene therapy, somatic virus germline gene therapy, mechanism of gene therapy, Immunotherapy. Detection of mutations in neoplastic diseases MCC, SSCP, DGGE, PTTC. Use of enzymes in clinical diagnosis. Use of biosensors for rapid clinicalanalysis. Diagnostic kit development for microanalysis, Diagnosis of disease by proteomics. 25 **Production of pharmaceuticals** Production of pharmaceuticals by genetically engineered cells (hormones, interferons). Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics). Techniques for development of new generation antibiotics. 15 Drug delivery
Text Books, and/or reference material	Suggested Text Book: 1. An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford Suggested Reference Book: 1. The Organic Chemistry of Drug Design and Drug Action; Richard B. Silverman, Elsevier

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	1	-	-	1	-	-	-	-
CO2	2	1	1	-	1	-	1	-	-	-	-	1
CO3	2	1	1	-	1	-	1	-	-	-	-	1
CO4	2	1	1	-	1	-	-	1	-	-	1	1

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE813	GM CROPS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC402 (Cell & Tissue Culture of Animals & Plants)		CT+MT+EA					
Course Outcomes	CO1: Development of knowledge of natural resistance / tolerance to various biotic and abiotic stress to plants. CO2: Development of ability to design strategy to genetically modify crop plants for quality improvement. CO3: Learning about the strategies toward generating environment friendly GM crops.						
Topics Covered	Introduction [2] Methods of genetic transformation [4] Genetic engineering of resistance to biotic stress [6] Genetic engineering of tolerance to abiotic stress [6] Genetic engineering for removal of environmental pollutants [4] Genetic engineering for quality nutrition and health [4] Genetic engineering for molecular farming [4] Biosafety concerns [4] Removal of selectable markers from GM crops [4] Modern tools of genetic manipulation of plants [4]						

Text Books, and/or reference material	Suggested Text Books: 1. H.S.Chawla, Introduction to Plant Biotechnology, Oxford & IBH Publishing co. Pvt..Ltd 2. Slater.A.,NigelW.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press. Suggested Reference Books: 1. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. 2. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice 1996 Elsevier

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1	1	2	1	1			1	1		1
CO2	1	2	2	1	3	2	2	3	2	1	1	2
CO3	1	2	3	2	3	2	2	1	2	1	1	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE814	BIOETHICS AND IPR	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To understand the nature of hazards related to biotechnology and the importance of biosafety in research. CO2: To learn and debate on different ethical issues of applications of Biotechnology research including recombinant DNA technology and Human trials. CO3:To realize the importance and basics of intellectual property Rights and laws implemented in this regard. CO4: To learn the basic way to file claim of a patent. CO5: To understand the idea about Entrepreneurship and its economic implication in the area of biotechnology research
Topics Covered	**Biotechnology and Society:** Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. (8) **Bioethics:** Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc. (6) **Biotechnology and Bioethics:** The expanding scope of ethics from biomedical practice to biotechnology, ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics. (7) Ethical dimensions of IPR, technology transfer and other global biotech issues. Jurisprudential definition and concept of property rights, duties and their correlations, history and evaluation of IPR – like patent design and copyright. Distinction among the various forms of IPR, requirements of a patent able invention like novelty, inventive step and prior art and state of

	art. (8) **Regulations on ethical principles in biomedical/ biotechnological practice:** The Nuremberg code, declaration of Helsinki; the Belmont report, co operational guidelines – WHO, guidelines of DBT (India), Guidelines of an informed consent Rights/ protection, infringement or violation, remedies against infringement, civil and criminal, Indian patent act 1970 and TRIPS major changes in Indian patent system, post-TRIPS effects. (7) Contents of patent specification and procedure for obtaining a) patents b) Geographical indication, c) WTO Detailed information on patenting biological products, Biodiversity (6)
Text Books, and/or reference material	Suggested Text Book: 1. F. H. Erbisch and K. M. Maredis, Intellectual Property Rights in Agricultural Biotechnology, Bios Publishers Suggested Reference Books: 1. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press. 2. Fleming, D.A., Hunt, D.L., (2000). Biological safety Principles and practices (3rd Ed). ASM Press, Washington. 3. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. 4. Encyclopaedia of Bioethics

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1			2		2				2
CO2			1			2		1				3
CO3						1	1	2				2
CO4								1	1	2		2
CO5						1	2	1		1	2	2

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE815</td><td>ENVIRONMENTAL MICROBIOME</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="4">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="4">Microbiology and Bioprocess Technology (BTC302); Molecular Biology and recombinant DNA Technology (BTC401) ; Bioinformatics (BTC601)</td><td colspan="5">CT+MT+EA</td></tr>
</table>

Course Outcomes	CO1: Develop understanding of Microbial Diversity and Ecology. Understand the Physicochemical and biological factors that define the microbiome in different environments as well as the significance of microbial interaction with environment CO2: Learn about the important tools and techniques used to study microbial ecology or microbiome structure. Learn to apply “Omics” approaches to assess the microbial community structure and function. CO3: Understand the System biology approach to assess the interaction and function of microbiome members in global scale. CO4: Learn to exploit microbial community members for Resource recovery, Environmental clean-up, CH4 production and consumption, CO2 sequestration, etc.
Topics Covered	**Introduction**- Significance, developments and challenges of environmental microbiome study. (4) **Microbial Diversity and ecology**- Environments and microenvironments, ecosystem services, biogeochemistry and nutrient cycles, carbon-nitrogen-sulfur-and other nutrient cycles. (7) **Survey of microbiome in different habitats-**Microbiomes of Terrestial, Marine, Freshwater, Deep sea, Hydrothermal vents, Subsurfaces, Permafrost region etc. Earth microbiome and Human microbiome Project. (7) **Microbiome of the built environment-** Microbial interactions with environment, microbial influenced corrosion, microbial enhanced oil recovery, mineral recovery, bioremediation of heavy metals and organic pollutants, methane production and consumption (7) **Microbiome characterization**- Metagenomics, metaproteomics and metatranscriptomics, culture dependent and culture independent techniques, conventional and molecular analyses, assessment of microbial metabolic diversity and activities. (8) **System Biology and Microbial interaction**- Approach of system biology in bioremediation, bioremediation with genomics, interaction between community members within microbiome, commensalism, syntrophism, interspecies hydrogen transfer etc. Strategies of bioremediation, Microbial performance assessment. (9)
Text Books, and/or reference material	Suggested Text Books**:** Brock Biology of Microorganisms- Madigan, Martinko, Bender, Buckley and Stahl- Pearson publisher. Bioremediation and Natural Attenuation: Process Fundamentals and Mathematical models- P J J Alvarez and W A Illman- Wiley Interscience. Suggested Reference Books: Environmental Microbiology: from genomes to biogeochemistry- Eugene L.Madsen- Blackwell Publishing. Environmental Microbiology for Engineers- V.Ivanov- CRC Press. Environmental Microbiology- Maier, Pepper and Gerba- Elsevier (Academic Press).

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	2	2	2	2	2	2	2	2	3	3
CO 2	3	3	3	3	3	2	2	2	2	3	3	3
CO 3	2	3	3	2	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO840	INDUSTRIAL BIOTECHNOLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Life science	CT+MT+EA

Course Outcomes	CO1- To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results CO-2 Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes CO-3 .Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques CO-4 Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation CO-5 Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation
Topics Covered	**UNIT 1 CELL CULTIVATION ,GROWTH KINETICS** -- 10 Hrs Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals.. **UNIT 2-MEDIA PREPARATIONand STERILIZATION** 10 Hrs Sterilization: basic concepts in sterilization insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter **UNIT 3- BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs** Purpose and importance of bioreactor, Parts of fermenter and types ;Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility'Operational modes of bioreactor: batch, semi-batch/fedbatch, continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor. **UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and A PPLICATIONS** -10Hour Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases). Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.

Text Books, and/or reference material	Suggested Text Books: 1. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011. Suggested Reference Books: 1. Ashok Pandey et al., "Enzyme Technology", Springer Publisher, 2006. 2. Nielsen et al., "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), "Downstream Processing of Proteins: Methods and Protocols", Humana Press, 2000. 4. Satinder Ahuja, "Handbook of Bioseparations", Vol 2, Academic Press, 1st Ed., 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1				-		-	
CO2	2	3	1	3	2	2	-		-		-	
CO3	1		1	2	2	2	-				-	
CO4	1	2	3	3	-	1	1					
CO5	1	2	3	3	1	2	1					

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO850	MEDICAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence. • CO2: Able to analyze the key features therapeutics and drugs in current scenario. • CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals. • CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.						
Topics Covered	**Microbial pathogenesis:** Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics. **Diagnosis of Infectious diseases**–Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy. **Drug Design and Drug delivery system :** Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques . New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics **Molecular Medicine:** Antibodies and vaccines-Therapeutic production of antibodies different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection .						

	Cell and tissue therapy – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery **Clinical Toxicology**, **Clinical Research Governance and Ethics:** Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation& drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. . International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.
Text Books, and/or reference material	Suggested Text Books: 1. Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press 2. Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons 3. S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers 4. Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA Suggested Reference Books: 1. Pharmaceutical Biotechnology ; Sambhamurthy&Kar , NewAge Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate 4. Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	1	1	2	2	1	-	-	-	-	-	2
CO 2	2	1	1	-	1	1	-	1	-	1	-	2
CO 3	2	1	1	1	1	1	-	1	-	1	1	2
CO4	2	1	1	1	1	2	2	2	1	1	2	2

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS855	Project-II	PCR	0	0	15	15	5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.						
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project.						

	Students are required to familiarize themselves with the literature review and scientific techniques and skills.
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Related research papers.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	2	2	2	3	3	3
CO2	3	2	2	3	2	2	1	1	1	2	3	3
CO3	3	3	3	2	2	2	1	3	3	1	3	3
CO4	3	3	3	2	3	3	2	3	2	2	3	3
CO5	3	3	3	3	3	3	2	3	3	3	3	3

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS852	PROJECT SEMINAR	PCR	0	0	0	0	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.						
Topics Covered	Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: • Related research papers.						

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3	2	3	3	3		3		3		3
CO2		2	1	3	2	2		3		3		3
CO3		3	1	3	2	2		3	2	3		3

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS853	VIVA VOCE	PCR	0	0	0	0	1

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NA	EA

Course Outcomes	**CO1:** To prepare the students to face future interviews. **CO2:** To develop logical thinking skills in the students.
Topics Covered	1. All the topics taught in core courses. 2. Topics taught in the elective courses.
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:**

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3			3				3		3
CO2	3	3	3			3				3		3

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING

2021 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in ______ Senate # ________________ # Item no: _______

DEPARTMENT OF CIVIL ENGINEERING

Program Name: Bachelor of Technology in Civil Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR CIVIL ENGINEERING - B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CEC301	Solid Mechanics	3	1	0	4.0	4
3	CEC302	Fluid Mechanics	3	0	0	3.0	3
4	CEC303	Building Construction and Concrete Technology	3	1	0	4.0	4
5	ESC331	Geology for Civil Engineering	3	0	0	3.0	3
6	ESS381	Geology Laboratory for Civil Engineering	0	0	3	1.5	3
7	CES351	Fluid Mechanics and Strength of Material Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	3	6	21.0	24
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CEC401	Structural Analysis-I	3	1	0	4.0	4
2	CEC402	Design of Concrete Structures	3	1	0	4.0	4
3	CEC403	Surveying	3	0	0	3.0	3
4	CSC432	Data Structure	3	0	0	3.0	3
5	YYO44*	Open Elective - I	3	0	0	3.0	3
6	CES451	Structural Analysis Sessional-I	0	0	3	1.5	3
7	CES452	Design of concrete Structures Sessional	0	0	3	1.5	3
8	CSS482	Data Structure Sessional	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	2	9	21.5	26
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CEC501	Structural Analysis-II	3	1	0	4.0	4
2	CEC502	Design of Steel Structures	3	1	0	4.0	4
3	CEC503	Soil Mechanics	3	0	0	3.0	3
4	CEC504	Transportation Engineering	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	CES551	Structural Analysis Sessional-II	0	0	3	1.5	3
7	CES552	Design of Steel Structures Sessional	0	0	3	1.5	3
8	CES553	Transportation Engineering and Soil Mechanics Laboratory	0	0	3	1.5	3
9	CES554	Surveying Laboratory and Estimation Sessional	1	0	3	2.5	4
10	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	16	3	12	25.0	31

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	CEC601	Water Resource Engineering	3	1	0	4.0	4
3	CEC602	Foundation Engineering	3	0	0	3.0	3
4	CEC603	Environmental Engineering	3	1	0	4.0	4
5	CEE610--	Depth Elective - 1	3	0	0	3.0	3
6	CEE610--	Depth Elective - 2	3	0	0	3.0	3
7	CES651	Environmental Engineering Laboratory and Computational Laboratory- I	0	0	3	1.5	3
8	CES652	Concrete Technology Laboratory	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	18	2	6	23.0	26
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	CEE710--	Depth Elective - 3	3	0	0	3.0	3
3	CEE720 --	Depth Elective - 4	3	0	0	3.0	3
4	CEE730 --	Depth Elective - 5	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	CES751	Project - I	0	0	4	2.0	4
7	CES752	Structural Engineering Laboratory and Computational Laboratory -II	0	0	3	1.5	3
8	CES753	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
		TOTAL	15	0	9	19.5	24
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CEE810--	Depth Elective - 6	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	CES851	Project - II	0	0	15	5.0	15
5	CES852	Project Seminar	0	0	0	1.0	0
6	CES853	Viva Voce	0	0	0	1.0	0
		TOTAL	9	0	15	16.0	24

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45.0	21.0	21.5	25.0	23.0	19.5	16.0	171.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF CIVIL ENGINEERING
CEE610	Advanced Design of Concrete Structures
CEE611	Advanced Structural Analysis
CEE612	Mechanics of Composite Structures
CEE613	Material Technology
CEE614	Applied Numerical Methods
CEE615	Bridge Engineering
CEE620	Analysis and Design of Pavement
CEE621	Finite Element Method
CEE622	Ground Improvement
CEE623	Remote sensing and GIS
CEE624	Traffic Engineering and Management
CEE625	System Approach to Civil Engineering

7th Semester

	DEPARTMENT OF CIVIL ENGINEERING
CEE710	Structural Dynamics
CEE711	Advanced Design of Steel Structures
CEE712	Theory of Plates and Shells
CEE713	Theory of Elasticity and Plasticity
CEE714	Structural Health Monitoring
CEE720	Soil Dynamics
CEE721	Environmental Pollution and control
CEE722	Construction Planning and Management
CEE723	Open Channel Hydraulics
CEE724	Ground Water

CEE725	Hydrology and Irrigation Engineering
CEE730	Principles of Reliability
CEE731	Offshore Structural Dynamics
CEE732	Pre-stressed Concrete
CEE733	Advanced Concrete Technology
CEE734	Advanced Structural Mechanics

8th Semester

	DEPARTMENT OF CIVIL ENGINEERING
CEE810	Sediment Transport
CEE811	Slope Stability and Reinforced Earth
CEE812	Soil Structure Interaction
CEE813	Industrial Waste
CEE814	Water Resources System Planning and Management
CEE815	Machine Foundation

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						

Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**

Pre-requisites:	Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA
Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill.

	REFERENCE BOOKS: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions,						

	octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	<u>Suggested Text Books:</u> (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall <u>Suggested Reference Books:</u> **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]

Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.						
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]						

Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]						

Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	Professional Communication Lab	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)						
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the						

	Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.						
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.						
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>WSS51</td><td>WORKSHOP PRACTICE</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
• CO1: Study and practice on machine tools and their operations
• CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
• CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
• CO4: Develop basic electrical engineering knowledge for house wiring practice</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
M/c shop & Carpentry shop -- 3X3= 9hrs.
• Introduction on machining process.
• Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
• Introduction to woods- Types, structure, disease and defect of wood.
• Introduction to wood working machines and tools.
• Making of dovetail joint and bridle joint.
Welding Shop & Sheet metal -- 3X3= 9hrs.
• Introduction to welding.Safety and precautions in welding.
• Formation of weld bead by SMAW on mild steel flat.
• Formation of weld bead by oxy-fuel welding on mild steel flat.
• Introduction to sheet Metal works.
• Tools and Machines used in sheet metal works.
• Concept of development, marking out of metal sheets.
• Cutting and joining of metal sheets.
• Safety precautions, General warning needed in the shop floor.
Black smithy & Foundry -- 3X3= 9hrs.
• Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
• Safety and precautions in blacksmithy.
• Making of bars of different cross-sections.
• Making of hexagonal headed bolts.
• Forge welding.
• Introduction to Foundry Technology.
• Preparation of sand mould using Solid/Split Pattern.
Fitting & Electrical shop -- 3X3= 9hrs.
• Introduction to hand metal cutting tools with specifications, nomenclature and their use.
• Marking tools, measuring tools and their use.</td></tr>
</table>

	• Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement

<table>
<tr><td></td><td>CO5: Exposure to social service</td></tr>
<tr><td>Topics Covered</td><td>YOGA

Introduction of Yoga.
Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar.
Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra.
Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani.
Meditation- Yognidra, Om chant, Pray chant.
Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana.
Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi.
Kriya- Kapalbhati, Trataka.

ATHLETICS

Introduction of Athletic.
Starting Technique for Track events- Standing start, Crouch & Block start.
Finishing Techniques.
Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules.
Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance.

BASKETBALL

Introduction and Players stance and ball handling.
Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass.
Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running.
Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble.
Rules of Basketball.
Basketball game.

VOLLEYBALL

Introduction of Volleyball
Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service.
Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set.
Rules and their interpretation.

FOOTBALL

Introduction of Football
</td></tr>
</table>

- Push pass- Instep inside, Instep outer side.
- Kicking- Spot kick, Instep kick, Lofted kick.
- Dribbling- One leg, Both legs, Instep.
- Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping.
- Throwing- Standing throw, Running throw, Seating throw.
- Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick.
- Rules and their interpretation.

CRICKET

- Introduction of Cricket
- Batting gripping & Stance, Bowling gripping technique.
- Batting front foot defense& Drive.
- Batting Back foot defense& Drive.
- Batting Square cut.
- Bowling medium pace, Bowling off break.
- Fielding drill, Catching (Short & High).
- Rules & Regulation.

BADMINTON

- Basic introduction about Badminton and Badminton court.
- Racket parts, Racket Grip, Shuttle Grip.
- Basic stance, Basic Footwork, Shadow practice (Full court movement).
- Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm.
- Match practice (Single & Double).
- Rules & Regulation.

TABLE TENNIS

- Introduction of Table Tennis.
- Basic Stance and Grip (Shake hand & Pen hold).
- Service Basic.
- Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Rules and their interpretations.
- Table Tennis Match (Singles & Doubles).

NCC

- FD-1 General Introduction and words of command.
- FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt.
- FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing.
- FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out.

- FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt.
- FD-7 Turning on the March and Wheeling.
- FD-12 Parade practice.

TAEKWONDO

- Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc.
- Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc.
- Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc.
- Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc.

NSS

- Swachha Bharat Mission
- Free Medical Camp
- Sanitation drive in and around the campus.
- Unnat Bharat Abhiyaan
- MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					
Course Outcomes	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.						

Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
	Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10^{th}ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3^{rd} Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC01</td><td>INTRODUCTION TO COMPUTING</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of computer.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates.
CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators.
CO3: Develop conditional and iterative statements to write C programs.
CO4: Exercise user defined functions to solve real time problems
CO5: Inscribe C programs that use Pointers to access arrays, strings and functions.
CO6: Exercise user defined data types including structures and unions to solve problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2]
Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1]
Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2]
Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1]
C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2]
Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8]
Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5]
Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5]
Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10]
Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium 1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons						

	1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback

	7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Overview of Electrical power generation systems (2)
Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4)
Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4)
Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8)
Transients with D.C. excitation for R-L and R-C circuits. (3)
Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC</td></tr>
<tr><td>Textbooks/Reference material</td><td colspan="7">Textbooks:
1. Electrical & Electronic Technology by Hughes, Pearson Education India
Reference Books:
1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd
2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis,

	TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition,

	Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)						

Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS51</td><td>COMPUTING LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques
• CO2: To detail out the operations of strings
• CO3: To understand structure, union
• CO4: Application of C-programming to solve various real time problems</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">List of Experiments:
1. Assignments on expression evaluation
2. Assignments on conditional branching, iterations, pattern matching
3. Assignments on function, recursion
4. Assignments on arrays, pointers, parameter passing
5. Assignments on string using array and pointers
6. Assignments on structures, union</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Let us C by Kanetkar
2. C Programming by Gottfried
3. Introduction to Computing by Balaguruswamy
4. The C-programming language by Dennis Ritchie
Reference Books:
1. Computer fundamental and programming in C by P Dey and M. Ghosh
2. Computer fundamental and programming in C by Reema Thareja
3. programming with C by Schaum Series</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS 51</td><td>Basic electronics Lab</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
</table>

Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output signals.
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td>ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">• CO1: understand the principle of superposition.
• CO2: understand the principle of maximum power transfer
• CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp.
• CO4: understand the calibration of energy meter.
• CO5: understand open circuit and short circuit test of single-phase transformer.
• CO6: analyze RLC series and parallel circuits
• CO7: understand three phase connections.
• C08: understand determination of B-H curve</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">List of Experiments:
1. To verify Superposition and Thevenin's Theorem.
2. To verify Norton and Maximum power transfer theorem
3. Characteristics of fluorescent and compact fluorescent lamp
4. Calibration on energy meter
5. To perform the open circuit and short circuit test on single phase transformer
6. To study the balanced three phase system for star and delta connected load
7. Characteristics of different types of Incandescent lamps
8. Study of Series and parallel R-L-C circuit
9. Determination of B-H Curve for magnetic material</td></tr>
<tr><td colspan="2">Textbooks, and/or reference material</td><td colspan="6">Textbooks:
1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma, H U Ezea
2. Laboratory Courses in Electrical Engineering (5th Ed) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Pub.)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3

CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing						

	• Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements.

	• Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service. • Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	3	3	1	2	-	-	-	-	1	-	-	-
	CO2	3	3	1	2	-	-	-	-	1	-	-	-
	CO3	3	3	1	2	-	-	-	-	1	-	1	1
	CO4	3	-	-	2	-	2	-	-	1	-	-	-
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1
CYC01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-
MAC02	CO1	2	3	1	3	-	-	-	-	2	-	-	-
	CO2	2	3	1	2	-	-	-	-	2	-	-	-
	CO3	2	2	2	3	2	-	-	-	3	-	1	1
	CO4	2	3	2	3	2	1	1	-	2	-	-	-

CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-
ECC01	CO1	-	-	-	-	-	-	-	-	-	-	-	-
	CO2	-	-	-	-	-	-	-	-	-	-	-	-
	CO3												
	CO4	-	-	-	-	-	-	-	-	-	-	-	-
EEC01	CO1	3	1	-	-	2	-	-	-	-	1	-	-
	CO2	2	3	2	-	2	-	-	-	-	-	-	-
	CO3	2	3	1	-	-	-	-	-	-	1	-	-
	CO4	3	1	2	-	1	-	-	-	-	-	-	-
	CO5	3	1	2	-	1	-	-	-	-	-	-	-
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-
EES51	CO1	3	-	2	-	3	-	-	-	1	-	-	-
	CO2	3	-	2	-	3	-	-	-	1	-	-	-
	CO3	2	3	2	2	1	-	2	-	1	-	-	-
	CO4	2	3	1	2	2	-	1	-	1	1	-	-
	CO5	2	3	1	2	2	-	-	-	1	-	-	-
	CO6	2	3	2	2	2	-	-	-	1	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-

	CO5	-	-	-	-	-	3	1	-	-	-	-	-

THIRD SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC301	**Solid Mechanics**	**PCR**	**3**	**1**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
Knowledge of Engineering Mechanics and Mathematics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs):	• CO1: Development of skills for predicting structural behaviour of solids under different loads • CO2: Knowledge of basics of analysis and design of structural components made of variety of materials • CO3: Developing the requisite skill that helps in studying the advanced courses
Topics Covered (Hrs)	**Concept of stress and strain**: Normal and shear stresses and strains in axially loaded members, Elastic moduli and their inter-relationships, strain energy due to direct stresses, impact loads. **(4)** **Beam Statics**: Definitions, support types and support reactions, concepts of redundancy, shear force and bending moment diagrams for beams. **(8)** **Symmetric Beam Bending**: Basic kinematical assumptions, moment of inertia, elastic flexure formulae and its application, moment carrying capacity. **(3)** **Bending stress and Shear stress distributions** in beam sections, Combined bending and direct stresses. **(8)** **Strain energy**: Due to pure bending and shearing stress. **(2)** **Deflection of beams**: Moment-curvature relationship, determination of deflection by direct integration method, moment area method and energy method. **(6)** **Torsion**: Pure torsion, Torsion of circular solid shaft, closed coil helical spring. Combined bending and torsion. **(4)** **Two dimensional stress problems**: Principal stresses, maximum shear stresses, Mohr's circle of stresses, construction of Mohr's circle. **(4)** **Thin pressure vessels**: Hoop stress and meridional stress, volumetric changes **(2)** **Columns**: Fundamentals, different types of equilibrium, column buckling theory, Euler's load for columns, limitations of Euler's theory – problems, eccentric load and secant formulae, empirical column formulae & IS code formulae. **(4)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Elements of Strength of Material by S. P. Timoshenko & D. H. Young 2. Strength of Materials by S SBhavikatti 3. Engineering Mechanics of Solids by E. P. Popov ***Reference Books:*** 4. Strength of Material by Singer &Pytel 5. A Text Book of Strength of Materials by Ghosh &Datta, New Age International Publication Pvt. Ltd, New Delhi

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	-	-	-	-	-	-	-	-	-
CO3	-	3	-	2	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC302	**Fluid Mechanics**	**PCR**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Development of skills for predicting fluid behaviour • CO2: Knowledge of basics of fluid flow measurement and model development • CO3: Developing the requisite skill that helps in studying the advanced courses						
Topics Covered (Hrs)	**Fluid Properties:** Equations of State, Units and Dimensions, Fluid Pressure, Pressure Gauges, Resultant Pressure on Plane and Curved Immersed Surfaces, Centre of Pressure, Equilibrium of Floating Bodies, Buoyancy and Meta Centre. **(9)** **Types of Flow**: Definitions, Continuity Equation, Equation of Flow along a Stream Line, Energy Equation, Momentum Equation, Fluid Acceleration, Flow in a Curved Path, Forced and Free Vortex. **(7)** **Dimensional Analysis**: Similitude of fluid flow, non-dimensional numbers. **(3)** **Incompressible flow in closed conduits**: Laminar and Turbulent Flow, Critical Reynold's Number, Pipe Friction Law, Laminar Flow in Pipes, Friction Loss in Smooth and Rough Pipes, Minor Losses in Pipes, HGL and EGL, Empirical Formula for Pipe flow. **(6)** **Flow measurement:** Orifice coefficient, External and Reentrant Mouth pieces, Measurement of Velocity and Discharge in Closed Conduits, Venturimeter, Orificemeter and Pitot Tube, Flow through Rectangular Weirs and V-Notch, Time of Emptying Tanks and Reservoirs. **(7)** **Open Channels:** Equation of Uniform Flow, Chezy and Manning Formulae, Velocity Distribution and Economic Cross Section. **(4)**						
Text Books, and/or reference material (s)	***Text Books:*** 1. Fluid Mechanics by Frank M White, Tata McGraw-Hill 2. Introduction to Fluid Mechanics byRobert W Fox & Alan T McDonald, WILEY 3. Fluid Mechanics by V. L. Streeter & E B Wylie, McGraw-Hill ***Reference Books:*** 4. Fluid Mechanics and Hydraulics by Jack B Evett& Cheng Liu, Tata McGraw-Hill						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	-	-	-	-	-	-
CO2	-	2	3	1	-	-	-	-	-	-	-	-
CO3	-	3	-	2	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC303	**Building Construction& Concrete Technology**	**PCR**	**3**	**1**	**0**	**4**	**4**
Pre-requisite(s)		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Acquire knowledge ofselection and application of building materials • CO2: Understand the building components and planning • CO3: Gain an integrative ideaon materials, preparation and mix design of concrete						

Topics Covered (Hrs)	**A). Building planning and construction:**Planning and orientation of buildings, Introduction to different components and functions of a building in details: Foundation, Wall, Beam, Floor, Roof, Stair &Staircase, Door, Window, and etc.**(10)** **B). Building Materials:** Brief idea on different building materials **(2)** **Aggregates:** Classification, sampling, mechanical, physical properties of fine and coarse aggregates, standard tests, deleterious substances, Alkali-aggregate reaction, thermal properties, grading of aggregate. **(4)** **Cement:** Introduction, chemical composition, major compounds, hydration, physical properties, testing, fineness, consistency, setting time, soundness, strength, heat of hydration, specific gravity, types of cement **(8)** **Water:** Source, quality, impurities and effect of on concrete, sea water **(2)** **Admixture:** Introduction, classification, specifications and functions of admixtures. **(2)** **Other materials:** Brick, Timber, Lime, Cement mortar, Timber, Steel and Paint. **(8)** **C). Concrete Technology:** Introduction, classification, properties, grades, advantage, disadvantages and quality control of concrete.**(2)** **Fresh concrete:** Introduction, workability, factors, measurement, segregation, bleeding and manufacture of concrete – batching, mixing, transporting, placing, compaction, finishing and curing.**(6)** **Hardened concrete:** Introduction, strength, stress–strain characteristics, destructive and non-destructive test, shrinkage, creep, permeability, durability, attack of sulphates, acid, efflorescence, thermal properties and fire resistance.**(4)** **Concrete mix design:** Factors andmix design using Indian Standard code. **(4)** **Special concrete:** Introduction of Light weight, High density, High strength, Fibre reinforced, Polymer concrete and Ferro cement. **(4)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Engineering Materials by S. C. Rangwala, K. S. Rangwala and P. S. Rangwala,Charotar Publishing House, Anand 2. Building Construction by S. C. Rangwala, Charotar Publishing House, Anand 3. Concrete Technology by M.S. Shetty, S. Chand Publisher, New Delhi 4. IS 10262: 2009,Concrete Mix Proportioning-Guidelines (1st Revision), BIS, New Delhi. 5. IS 383: 1970, Specification for Coarse and Fine aggregates from natural sources for concrete (2nd Revision) BIS, New Delhi. ***Reference Books:*** 6. Concrete Technology by M.L. Gambhir, Tata McGraw Hill and www.nptel.ac.in

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	2	1	-	-	-	-	-
CO2	3	-	-	-	-	2	1	-	-	-	-	-
CO3	3	-	3	-	-	2	1	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES351	**Fluid and Strength of Material Laboratory**	**PS**	**0**	**0**	**3**	**3**	**1.5**
Pre-requisite(s)		Course Assessment methods					
NIL		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	• CO1: Conduct experiments for the determining the properties of harden concrete and mild steel, and other construction materials.						

(COs) :	• CO2: Perform different experiments on fluid mechanics related problems for determination of properties of flow through pipes and calibration of few flow rate measuring instruments. • CO3: Use modern instruments and tools to determine the properties of harden concrete and other civil engineering materials and work in a group. • CO4: Prepare the report on experimental results.
Topics Covered (Hrs)	Determination of compressive strength, split tensile strength & flexural strength of concrete. To observe the behavior of a mild steel specimen while being tested and to determine (i) upper and lower yield points, (ii) ultimate strength, (iii) breaking strength, (iv) percentage elongation of length, (v) percentage reduction of cross-section. To apply torsional load on circular rods and to determine the value of modulus of rigidity by measuring the angle of twist. Experiment on Rockwell Hardness Test. Determination of coefficient of bend loss in flow through pipes. Experiment on friction loss in flow through pipes. Calibration of Venturimeter. Calibration of V-notch. Calibration of Orifice meter. Experiment on impact of jet.
Text Books and/or reference material(s)	***Text Books:*** 1. Concrete Technology by M. S. Shetty, S. Chand & Co 2. Concrete Technology by M. L. Gambhir, Tata McGraw Hill 3. Elements of Strength of Material by S. P. Timoshenko, and D. H. Young, Affiliated East-West Press. ***Reference Books:*** 3. Fluid Mechanics by M White Frank, Tata McGraw-Hill 4. Introduction to Fluid Mechanics by W Fox Robert & T Alan McDonald, WILEY 5. Fluid Mechanics by V. L. Streeter, & E B, Wylie, McGraw-Hill.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	3	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-
CO3	-	-	-	2	3	-	-	-	2	-	-	-
CO4	-	-	-	1	-	-	-	-	1	3	-	-

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	**MATHEMATICS-III**	**PCR**	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Basic knowledge of topics included in MAC01 & MAC02					
Course Outcomes	• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. • CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. • CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. • CO4: To understand the optimization methods and algorithms developed for						

	solving various types of optimization problems.
Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:**Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar& R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC331	CO1	3	3	3	2	2	1	2	-	-	-	-	2
	CO2	3	3	2	2	2	1	2	-	-	-	1	2
	CO3	3	3	2	2	3	-	1	-	-	1	-	2
	CO4	3	2	2	3	2	1	1	-	1	-	-	2

<table>
<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>ESC331</td><td>Enginnering Geology for Civil Engineering</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• Assimilation of Geological knowledge with Civil Engineering for better design of Engineering Structures (Dam, Tunnels etc.).
• Enhancing skill of problem solving in dam, tunnel and landslide etc.
• Better understanding of groundwater as a vital resource in Water Resource Engineering.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Mineralogy: Definition, simple classifications, examples; Physical properties of minerals, chemical characteristics, occurrence [2]
Petrology: Three types of rocks – Igneous, Sedimentary, Metamorphic, Igneous rocks – definition, classifications and examples, structures of intrusive and extrusive rocks, textures; Sedimentary rocks – Origin, classifications and examples, primary structures, textures; Metamorphic rocks – roles of agents of metamorphism, types of metamorphism, grades and degrees of metamorphism, metamorphic textures. [10]
Structural Geology: Strike and Dip of planes, True dip, Apparent dip; Folds – Hinge, limbs, axis, axial plane, types of folds; Faults – Common terms for describing faults, types and classification of faults; Joints – Definition, types and classification of joints; Cleavage and Schistosity – Definitions and types of cleavages. [5]
Hydrogeology: Groundwater occurrence, vertical distribution, water bearing properties of rocks- porosity, retention, yield, permeability, Zone of aeration and saturation, perched water table, Coefficient of storage, Natural springs & seepages, Recharge and Discharge area criteria, Geological Control on groundwater movement – Darcy's law, Fluctuation of water table in unconfined aquifer, Cone of depression, Groundwater exploration, Effects of excessive trapping, Water logging, Water well. [8]
Engineering Geology: Engineering properties of rocks – drifted rocks, in situ rocks, Building materials, Strength characteristics, Geological characteristics, general characteristics, Dams & Reservoirs, Tunnel, Landslide, Bridge. [8]
Physical Geology: Gradation of a country; Geological works of wind and Running water. [3]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1) A Textbook of Geology : P. K. Mukherjee, World Press
2) Engineering Geology: Subinoy Gangopadhyay, Oxford University Press
3) The Principles of Petrology : G. W. Tyrrel; B. I. Publications
4) Groundwater Hydrology : D. K. Todd, Wiley Student Edition
5) Textbook of General and Engineering Geology: Prabin Singh; S. K. Kataria& Sons</td></tr>
</table>

<table>
<tr><td colspan="9">Department of Earth and Environmental Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>ESS381</td><td colspan="2">Geology Laboratory For Civil Engineers</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) assessment)</td></tr>
<tr><td colspan="3"></td><td colspan="6">CT</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">• Students will be able to know the characters of the minerals and rocks on which the Civil structures to be constructed.
• The students will learn to solve geological problems associated with selection of construction site.
• The students will have firsthand knowledge of geophysical exploration for groundwater.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Experiment 1: To study the physical properties of minerals in hand specimens. [3]
Experiment 2: Identification of minerals in hand specimens on the basis of physical properties. [3]
Experiment 3: Study of rocks in hand specimens. [3]
Experiment 4: Determination of apparent dips in given directions from true dip. [3]
Experiment 5: Determination of true dip from given apparent dips. [3]
Experiment 6: Determination of orientation of inclined plane from drill hole data. [3]
Experiment 7: Study of a geological map. [3]
Experiment 8: Resistivity survey for subsurface water (Part 1). [3]
Experiment 9: Resistivity survey for subsurface water (Part 2). [3]</td></tr>
</table>

FOURTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC401	**Structural Analysis-I**	**PCR**	**3**	**1**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
Engineering &Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Acquire the knowledge of structural systems, elements, joints, loads, stability, equilibrium, compatibility and indeterminacy • CO2: Able to computethe internal forces in cable, arch, trusses, beams and frames • CO3: Achieved the idea to applygeometric methods to obtain slope and deflections • CO4: Gain the idea to apply Energy methods to obtain slope and deflections • CO5: Evaluate & draw the influence lines for reactions, shears, & bending moments in beams & girders due to moving load.
Topics Covered (Hrs)	**Introduction:** Structural system, support condition different load and system**(2)** **Shear force and bending moment:**Recapitulation of bending moment and shear force of determinate structures.**(4)** **Slopes and deflections:** Slopes and deflections in beams and frames, elastic curve, application of elastic beam theory with Maculay's notation, moment area method, conjugate beam method. **(14)** **Energy methods:**Strain energy, complementary energy, real work, virtual work, applicationofCastigliano's Theorems & virtual work methods to beams, frames, trusses, Maxwell's Reciprocal theorem, Betti's Law **(18)** **Static and kinematic indeterminacy:**Application on different type of structures**(4)** **Influence Lines:** Application of influence lines & rolling loads for determinate beams / girders**(10)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Basic Structural Analysis by C. S. Reddy, Tata McGraw Hill 2. Elementary Structural Analysis by Wilbur & Norris, Mcgraw-Hill College 3. Elements of structural analysis by N. C. Sinha, New Central book agency pvt. Ltd. 4. Structural Analysis by R. C. Hibbeler, Pearson Education ***Reference Books:*** 5. Structural Analysis by G. S. Pandit& S. P. Gupta, Tata McGraw Hill 6. Theory of structures by S. P. Timoshenko and D. H. Young, Mc. Graw Hill book Co

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	3	-	-	-	-	-	1	-	-	-	-	-
CO3	3	-	-	-	2	-	-	-	-	-	-	-
CO4	3	-	-	-	2	-	-	-	-	-	-	-
CO5	3	-	-	-	2	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC402	**Design of Concrete Structures**	**PCR**	**3**	**1**	**0**	**1**	**4**
Pre-requisite(s)		Course Assessment methods					
Solid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Apply knowledge of solid mechanics for design solutions. • CO2: Understand basic design philosophies applicable to concrete structures. • CO3: Formulate, analyze, and designbasic components of Civil Engineering Reinforced Concrete structures.						
Topics Covered (Hrs)	**Properties** of concrete and reinforcing steel, Characteristic strengths, Stress strain curves, Shrinkage and creep phenomenon, I.S. specification **(4)** **Design philosophies** – working stress method and limit state method of design. **(8)** **Analysis and design** of sections in flexure by working stress and limit state method, Single and doubly reinforced sections, T and L sections **(8)** **Behaviour of beams** in shear and bond, Design for shear, Anchorage and curtailment of reinforcement, Detailing of reinforcement. **(4)** **Serviceability**, Limit states of deflection and cracking, Calculation of deflections. **(4)** **Design of columns**: Short and long columns, Eccentrically loaded columns **(8)** **Design of one-way and two-way slabs, Staircases. (6)** **Isolated and combined footings (6)** **Design of cantilever type retaining walls(6)**						
Text Books, and/or reference material(s)	***Text Books:*** 1. Reinforced Concrete Design, 2nd Edition, by S. Unnikrishna Pillai and Devdas Menon, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003. 2. IS 456: 2000,Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi. 3. SP-16, Design Aids for Reinforced Concrete to IS: 456 – 1978, BIS, New Delhi 4. www.nptel.iitm.ac.in/courses/ ***Reference Books:*** 5. Reinforced Concrete, 6th Edition, by S.K. Mallick and A.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, 1996. 6. Reinforced Concrete Design, 1st Revised Edition, by S.N. Sinha, Tata McGraw-Hill Publishing Company. New Delhi, 1990.						

Mapping of Course Outcomes COs→POs

	Engineering knowledge	Problem analysis	Design/development of solutions	investigations of complex	Modern tool usage	The engineer and society	Environment & sustainability	Ethics	Individual & team work	Communication	Project management & finance	Life-long learning
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC 403	**Surveying**	**PCR**	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods					
None		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes	• CO1: Learn basic principles of surveying and handling of various surveying instruments. • CO2: Learn toconduct engineering surveys. • CO3: Data entry in field books and level books. • CO4: Make and interpret maps. • CO5: Compute area and volumes.
Topics Covered (Hrs)	**Introduction:** Definition, primary division,classification and Principles of surveying, Basic measurements. **(2)** **Linear measurements:** Instruments, Ranging, Chaining, Tape corrections. **(3)** **Chain surveying:** Principles, Basic definitions, Equipment, Field work, Obstacles, Plotting & accuracy. **(3)** **Compass surveying:** Instruments, Traverse, Bearings and their designations, Magnetic declination, Magnetic & true bearings, Field work, Plotting & adjustment of a closed traverse.**(3)** **Levelling:** Basic definitions, Instruments and their adjustments, Principles of levelling, Fieldwork and writing level books, Profile levelling & cross-sectioning, Reciprocal levelling, Difficulties in levelling, Errors. **(4)** **Contouring:** Basic definitions, Methods of locating contours, Characteristic of contours, Use of contour maps. **(2)** **Plane Table surveying:** Introduction and basic definitions, Instruments and their uses, Principles of plane tabling, Methods of plane tabling, Three point problems and its solutions, Two-point problem and its solution, Errors in plane tabling, Advantages and disadvantages. (3) **Theodolite:** Different parts, Temporary adjustments, Fundamental lines, Permanent adjustments, Measurement of horizontal and vertical angles. **(4)** **Theodolite Traversing:** Introduction and basic definitions, Field work, Angular measurements, Traverse computations, Balancing of the traverse, Accuracy of traverse surveying. **(5)** **Measurement of areas:** Area of a tract with irregular boundaries, Different methods, Planimeter and its uses. **(5)** **Measurement of volumes:** Computation of area of cross sections for different sections, Computation of volumes by different methods, Volume from contour map, Capacity of reservoir, Volume from spot levels, Mass-Haul diagram – its characteristics and uses. **(4)** **Electromagnetic distance measurements:** Working principle of EDM equipment, Uses, Range, Accuracy, Corrections to be applied to horizontal distances.**(4)**
Text Books, and/or reference material	***Text Books:*** 1. Surveying and Levelling Part I& II by T. P. Kanetkar and S. V. Kulkarni, Pune VidyarthiGrihaPrakashan Pune – 30, 1979 2. Surveying Vol. I& II. by, B. C. Punmia, A. K. Jain and A. K. Jain A.K., Laxmi Publications (P) Ltd., 2005 ***Reference Books:*** ***3.*** Surveying Vol. I.& II by K. R. Arora, Standard Book House, P.B.-1074, Delhi ***4.*** Surveying courses available in http://nptel.iitm.ac.in/

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	-	-	3	-
CO2	-	-	-	-	-	-	-	-	-	-	3	-

CO3	-	-	-	-	-	-	-	-	-	-	3	-
CO4	-	-	-	-	-	-	-	-	-	-	3	-
CO5	-	-	-	-	-	-	-	-	-	-	3	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES451	**Structural Analysis Sessional-I**	**PS**	**0**	**0**	**3**	**3**	**1.5**

Pre-requisite(s)	Course Assessment methods
Engineering &Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: Acquire the knowledge of structural systems, elements, joints, loads, stability, equilibrium, compatibility and indeterminacy
- CO2: Able to computethe internal forces in cable, arch, trusses, beams and frames
- CO3: Achieved the idea to applygeometric methods to obtain slope and deflections
- CO4: Gain the idea to apply Energy methods to obtain slope and deflections
- CO5: Evaluate & draw the influence lines for reactions, shears, & bending moments in beams / girders due to moving load.

Topics Covered (Hrs)

Introduction: Structural system, support condition different load and system**(1)**
Shear force and bending moment: Recapitulation of bending moment and shear force of determinate structures.**(2)**
Slopes and deflections: Slopes and deflections in beams and frames, elastic curve, application of elastic beam theory with Maculay's notation, moment area method, conjugate beam method. **(12)**
Energy methods: Strain energy, complementary energy, real work, virtual work, applicationofCastigliano's Theorems & virtual work methods to beams, frames, trusses, Maxwell's Reciprocal theorem, Betti's Law **(12)**
Static and kinematic indeterminacy: Application on different type of structures**(3)**
Influence Lines: Application of influence lines & rolling loads for determinate beams / girders**(9)**

Text Books, and/or reference material (s)

Text Books:

1. Basic Structural Analysis by C. S. Reddy, Tata McGraw Hill
2. Elementary Structural Analysis by Wilbur& Norris, Mcgraw-Hill College
3. Elements of structural analysis by N. C. Sinha, New Central book agency pvt. Ltd.
4. Structural Analysis by R. C. Hibbeler, Pearson Education

Reference Books:

5. Structural Analysis by G. S. Pandit& S. P. Gupta, Tata McGraw Hill
6. Theory of structures by S. P. Timoshenko and D. H. Young, Mc. Graw Hill book Co

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	3	-	-	-	-	-	1	-	-	-	-	-
CO3	3	-	-	-	2	-	-	-	-	-	-	-
CO4	3	-	-	-	2	-	-	-	-	-	-	-
CO4	3	-	-	-	2							

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES452	Design of Concrete Structures sessional	PS	0	0	3	3	1.5

Pre-requisite(s)	Course Assessment methods
Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: Apply knowledge of solid mechanics for design solutions.
- CO2: Understand basic design philosophies applicable to concrete structures.
- CO3: Formulate, analyze, and design basic components of Civil Engineering Reinforced Concrete structures.

Topics Covered (Hrs)

Properties of concrete and reinforcing steel, Characteristic strengths, Stress strain curves, Shrinkage and creep phenomenon, I.S. specification **(4)**
Design philosophies – working stress method and limit state method of design. **(8)**
Analysis and design of sections in flexure by working stress and limit state method, Single and doubly reinforced sections, T and L sections **(8)**
Behaviour of beams in shear and bond, Design for shear, Anchorage and curtailment of reinforcement, Detailing of reinforcement. **(4)**
Serviceability, Limit states of deflection and cracking, Calculation of deflections. **(4)**
Design of columns: Short and long columns, eccentrically loaded columns **(8)**
Design of one-way and two-way slabs, Staircases. (6)
Isolated and combined footings (6)
Design of cantilever type retaining walls (6)

Text Books, and/or reference material(s)

Text Books:

1. Reinforced Concrete Design, 2nd Edition, by S. Unnikrishna Pillai and Devdas Menon, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
2. IS 456: 2000, Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi.
3. SP-16, Design Aids for Reinforced Concrete to IS: 456 – 1978, BIS, New Delhi
4. www.nptel.iitm.ac.in/courses/

Reference Books:

5. Reinforced Concrete, 6th Edition, by S. K. Mallick and A.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, 1996.
6. Reinforced Concrete Design, 1st Revised Edition, by S.N. Sinha, Tata McGraw-Hill Publishing Company. New Delhi, 1990.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC432	**Data Structure**	**PCR**	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods: (Continuous (CT), Mid-Term (MT) and End Assessment (EA)
CSC 01 in 1st year	CT+MT+EA

Course Outcomes	At the end of the course, a student will be able to: CO1.Describe linear data structures using array and linked list CO2. Apply data structures like stacks, queues in linear data structure. CO3. Discuss non-linear data structures tree and its application. CO4. Apply various algorithms in graph. CO5. Solve searching, sorting and hashing techniques in data structures CO6. Interpret sorting algorithms for a given problem.
Topics Covered	**Fundamentals of Python:** Basic Python programming, Data types, while & for loops, if-else statements, function, List, Tuples and Dictionary, file handling, Object & Classes.[10] **Searching Techniques:** Linear search, Binary search, Fibonacci search. [4] **Sorting Techniques:** Bubble sort, Insertion sort, Selection sort, Quick sort, Merge sort. [5] **Single Linked List:** Implementation of Single Linked List and different operation like (i) Creation (ii) insertion (iii) deletion (iv)traversal. Implementation of Circular Linked List using single linked list.[4] **Double Linked List:** Implementation of Single Linked List and different operation like (i) Creation (ii) insertion (iii) deletion (iv)traversal. [3] **Stack and Queue:** Design and Implementation of Stack and Queue and different operation on them, Stack operations to convert infix expression into postfixexpression, Stack operations for evaluating the postfixexpression. [8] **Graph:** Implementation of Graph, Depth first search, Breadth first search. [5] **Binary Search Tree:** Design and Implementation of Binary search tree, Traverse the above binary search tree recursively in pre-order, post-order andin-order. Count the number of nodes in the binary searchtree. [6]
Text Books, and/or reference material	**Text Books** 1. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley StudentEdition. 2. Michael T. Goodrich, Robert Tamassia, Michael H. Goldwasser, "Data Structures and Algorithms in Python", Wiley. **References:** 3. https://docs.python.org/3/tutorial/datastructures.html 4. http://www.tutorialspoint.com/data_structures_algorithms

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	1	2	1		1	1	1				2	-	-	1
CO2	3	2	1	1	1	1	1	1	1	1		2	1	1	1
CO3	3	3	2	1	1	1	1	1	1	1	1	1	2	2	1

Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS482	**Data Structure Sessional**	**PCR**	**0**	**0**	**3**	**3**	**1.5**

Pre-requisites	Course Assessment methods: (Continuous evaluation (CE) and End Assessment (EA))
CSS 51 in 1st year.	CE+EA

Course Outcomes

At the end of the course, a student will be able to:
CO1. **Understand** various data representation techniques in the realworld.
CO2. **Implement** linear and non-linear datastructures.
CO3. **Analyze** various algorithms based on their time and spacecomplexity.
CO4. **Develop** real-time applications using suitable datastructure.
CO5. **Identify** suitable data structure to solve various computingproblems.

Topics Covered

List of Experiments:

Week1: Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order

a. Linearsearch
b. Binary search
c. Fibonaccisearch

Week2: Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order.

a. Bubblesort
b. Insertionsort
c. Selectionsort

Week3: Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order.

a. Quicksort
b. Mergesort

Week4: Write Python programs to

a. Design and implement Stack and its operations using List.
b. Design and implement Queue and its operations using List.

Week5: Write Python programs for the following:

a. Uses Stack operations to convert infix expression into postfix expression.
b. Uses Stack operations for evaluating the postfix expression.

Week6: Write Python programs for the following operations on Single Linked List.

a. (i) Creation (ii) insertion (iii) deletion (iv) traversal
b. To store a polynomial expression in memory using single linked list.

Week7: Write Python programs for the following operations on Circular Linked List.

(i) Creation (ii) insertion (iii) deletion (iv) traversal

Week8: Write Python programs for the following:

Uses functions to perform the following operations on Double Linked List.
(i) Creation (ii) insertion (iii) deletion (iv) traversal in both ways.

Week9: Write a Python program to implement Stack using linked list.

Week10: Write a Python program to implement Linear Queue using linked list.

Week11: Write Python programs to implement the following graph traversal algorithms:

a. Depth first search.
b. Breadth first search.

Week12: Write a Python program to perform the following:

	a. Create a binary search tree. b. Traverse the above binary search tree recursively in pre-order, post-order and in-order. c. Count the number of nodes in the binary search tree.
Text Books, and/or reference material	**Text Books** 1. Y Daniel Liang, "Introduction to Programming using Python",Pearson. 2. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley StudentEdition. 3. Michael T. Goodrich, Robert Tamassia, Michael h. Goldwasser, "Data Structures and Algorithms in Python", Wiley. **References:** 1. https://docs.python.org/3/tutorial/datastructures.html 2. http://interactivepython.org/runestone/static/pythonds/index.html 3. http://www.tutorialspoint.com/data_structures_algorithms 4. http://www.geeksforgeeks.org/data-structures/

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1					1	1	1		2	1		1
CO2	3	2	1					1	1	1		2	1		1
CO3	3	2	1		1	1	1	1	1	1		2	2		1

FIFTH SEMESTER

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEC501</td><td>Structural Analysis-II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">Solid Mechanics &Structural Analysis-I</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Analyse indeterminate beams and frames by displacement methods (Slope deflection method, Moment distribution method, Kane's method)
• CO2: Analyse indeterminate beams and frames by force methods (Three moment Equation, column Analogy method, consistent deformation method)
• CO3: Apply matrix analysis using stiffness and flexibility methods- computer-based analysis of structure.
• CO4: Evaluate and draw the influence lines for reactions, shears, and bending moments in indeterminate beams / girders and frames.
• CO5: Apply approximate methods (Substitute Frame method, Portal and cantilever methods) to solve multi-storeyed building frames</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Displacement methods: Application of Slope deflection, Moment distribution &Kani's method to indeterminate beams, frames & portals(16)
Force methods: Application of Three moment equations to continuous beam, executionof Column analogy &Consistent deformation method to beams & frames (12)
Influence lines:Indeterminate structures, Muller Breslau principle with application to redundant beams(8)
Matrix Method: Matrix formulationof flexibility & stiffness methods of structures-application for simple loading cases (10)
Approximate methods: Substitute frames, Portal & Cantilever methods on multi-storeyed building frames (6)</td></tr>
<tr><td>Text Books, and/or reference material (s)</td><td colspan="7">Text Books:
1. Basic Structural Analysis by C. S. Reddy, Tata McGraw Hill
2. Elementary Structural Analysis by Wilbur & Norris, Mcgraw-Hill College
3. Structural Analysis L. S. Negi & R. S. Jangid, Tata McGraw Hill
4. Structural Analysis by R. C. Hibbeler, Pearson Education
Reference Books:
5. Structural Analysis by G. S. Pandit& S. P. Gupta, Tata McGraw Hill
6. Intermediate structure analysis by C K Wang Mc. Graw Hill</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	Engineering knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment & sustainability	Ethics	Individual & team work	Communication	Project management & finance	Life-long learning
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	2	-	-	-	-	-	-	-
CO2	3	-	-	-	2	-	-	-	-	-	-	-
CO3	3	-	-	-	2	-	-	-	-	1	-	-
CO4	3	-	-	-	2	-	-	-	-	-	-	-
CO5	3	-	1	-	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC502	**Design of Steel Structures**	**PCR**	**3**	**1**	**0**	**4**	**4**
Pre-requisite(s)		Course Assessment methods					
Solid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Apply knowledge of solid mechanics for design solutions. • CO2: Understand basic design philosophy applicable to steel structures. • CO3: Formulate, analyze, and designbasic components of Civil Engineering Steel structures.						
Topics Covered (Hrs)	**Introduction**, Properties of structural steel, I.S. rolled sections, I.S. specifications **(2)** **Design philosophy** of Limit State method for Steel Structures**(6)** **Design of Tension members**, Compression members in truss**(6)** **Design of Beams** (laterally supported /unsupported) : Simple beam using rolled sections, Built up sections /compound beams **(6)** **Design of Gantry girders(4)** **Design of Plate girders**, Connections, Stiffeners and curtailment of flange plates, Splicing – riveted and welded. **(2)** **Design of Simple Connections**: Riveted, Bolted and welded connections, moment resisting connections**. (6)** **Design of Struts and columns** including built-up columns under axial and eccentric loadings, Lacing and battens, Column splicing. **(6)** **Design of Column bases** – slab base, Gusseted base. **(4)**						
Text Books, and/or reference material(s)	***Text Books:*** 1. Design of steel Structures by N. Subrhamanium (Oxford publications) 2. IS 800-2007: General Construction in Steel-Code of Practice 3. IS 808-1989: Dimensions of Hot Rolled Steel beam, column, channel and angle sections 4. www.nptel.iitm.ac.in/courses/ ***Reference Books:*** 5. Limit State Design of Steel Structures by S.K. Duggal (McGraw Hill publications) 6. Limit State Design of Steel structures by VirendraGehlot&Dr. Ram Chandra (Scientific publisher) 7. Design of steel Structures by S. S. Bhavikatti (IK Intl Publishing House, N Delhi)						

Mapping of Course Outcomes COs→POs

	Engineering knowledge	Problem analysis	Design/development of solutions	investigations of complex	Modern tool usage	The engineer and society	Environment & sustainability	Ethics	Individual & team work	Communication	Project management & finance	Life-long learning
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC503	**Soil Mechanics**	**PCR**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering and Fluid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Acquire knowledge of classifying the soil from Civil Engg. Aspect • CO2: Ability to conduct Experiment and Analyze the data with interpretation • CO3: Ability to analyze Soil for Soil-Structure like Dams (Earthen/Rigid) • CO4: Ability to Design Soil related Civil Engg. Structure • CO5: Understanding need of the Professional Ethics & future studies						
Topics Covered (Hrs)	**Introduction:**Type of soil, Mineralogical composition, Basic definitions of soil parameters, Inter-phase relationships, Problems **(4)** **Index properties:**Index properties of soils and their determination, classification based on index properties. Problems **(4)** **Classification:**Various classification systems, IS, MIT, US bureau and soil classification, PRA, Plasticity chart. Group Index. Problems. **(3)** **Soil-Water Pressure:**Total, effective, and pore pressure in soil. Capillary rise, effect of seepage on pore pressure, Quick condition. Problems. **(3)** **Permeability:**Permeability and seepage through soil, Darcy's law, Determination of permeability by laboratory methods and field methods. Factors affecting permeability. Flow through stratified soil. Problems. **(4)** **Seepage analysis:**Laplace's equation for Isotropic & an-isotropic soils, Flow-nets, Seepage through sub-soil, earthen embankment& piping failure, Problems **(4)** **Stress distribution:**Stress distribution in soils, point loads, line loads, strip loads, rectangular footings, circular footings, arbitrary footings. Boussineq's equation, Westtergards' equation, Newmarks's equation. Significant depth, pressure bulb, Newmark's influence coefficients, stress due to linearly varying loads. Problems. **(5)** **Consolidation:**One-dimensional Consolidation theory, Oedometer test, e-$\log_{10}$P curve, settlement&its time required, determination of C_v, m_v, C_c. Definition of Normally &Overconsolidated soils. Problems. **(7)** **Compaction:**Compaction, Standard Proctor Test, Modified Proctor Test, γ_d vs ω curve. Field compaction tests and Field compaction. Problems. **(3)**						
Text Books, and/or reference material (s)	***Text Books:*** 1. Soil Mechanics and Foundation Engineering by V N S Murthy,CBS publisher and Distributor 2. Soil Mechanics and Foundation Engineering by S.K. Garg, Khanna Publishers 3. Basic and Applied Soil Mechanics by Gopal Ranjan& A.S.R. Rao, New Age International ***Reference Books:*** 4. Advanced Soil Mechanics by B.M. Das, McGraw Hills Publishers						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	3	-	-	-	-	-	-	-	-
CO3	1	3	3	-	-	-	-	-	-	-	1	-
CO4	-	2	3	2	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	3	-	-	2

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEC504</td><td>Transportation Engineering</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">None</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Apply knowledge of transportation engineering for planning & design solutions.
• CO2: Understand basic design philosophy applicable to components of transportation engineering.
• CO3: Formulate, analyze, & design basic components of transportation engineering.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Highway planning, Geometric Design of elements. (6)
Highway construction: Materials - desirable properties and quality control tests; Design of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible pavement using IRC: 37-2012; Design of rigid pavements using IRC: 58-2011; Distresses in concrete pavements; Environmental impact, Highway maintenance. (12)
Principle of Transportation, Different modes of transportation and their characteristics, Scope and limitations. Traffic Engineering, Traffic studies on flow, speed, travel time - delay and O-D study, PCU, peak hour factor, parking study, accident study and analysis, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Control devices, signal design by Webster's method; Types of intersections and channelization; Highway capacity and level of service of rural highways and urban roads. (12)
Airport planning, Site selection, Obstructions and zoning laws, Geometric standards of landing area, Runway orientations, Airport runway length, taxiway and exit taxiway design, Visual aids, Introduction to air-traffic control. (10)
Development of railways in India, Track components and materials, Geometric design elements, Tractive resistances, Layout of points and crossings, High speed track, Marshalling yards, Signaling and interlocking, Track materials and maintenance. (10)
Requirements of good docks and harbours, Types of docks, Whaff-walls, Lock-gates, Wave action, Littoral drift, Breakwaters, Jetties, Dredging. (6)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Highway, Railway, Airport and Harbour Engg.by K.P. Subramanian, Scitech Publication
2. Airport Engineering by Rangwala, Chrotar Publishing
3. Railway Engineering by Saxena and Arora, Dhanapat Rai Publication
Reference Books:
4. Highway Engineering by S. K. Khanna, C.E.G. Justo and A. Veeraraghavan, Nemchand& Bros.
5. Harbour, Dock and Tunnel Engineering by R. Srinivasan, Charotar Publishing</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CES551</td><td>Structural Analysis Sessional-II</td><td>PS</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">Solid Mechanics &Structural Analysis-I</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Analyse indeterminate beams and frames by displacement methods (Slope deflection method, Moment distribution method, Kane’s method)
• CO2: Analyse indeterminate beams and frames by force methods (Three moment Equation, column Analogy method, consistent deformation method)
• CO3: Apply matrix analysis using stiffness and flexibility methods- computer-based analysis of structure.
• CO4: Evaluate and draw the influence lines for reactions, shears, and bending moments in indeterminate beams / girders and frames.
• CO5: Apply approximate methods (Substitute Frame method, Portal and cantilever methods) to solve multi-storeyed building frames</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Displacement methods: Application of Slope deflection, Moment distribution &Kani’s method to indeterminate beams, frames & portals(12)
Force methods: Application of Three moment equations to continuous beam, executionof Column analogy &Consistent deformation method to beams & frames (9)
Influence lines:Indeterminate structures, Muller Breslau principle with application to redundant beams(6)
Matrix Method: Matrix formulationof flexibility & stiffness methods of structures-application for simple loading cases (6)
Approximate methods: Substitute frames, Portal & Cantilever methods on multi-storeyed building frames (6)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Basic Structural Analysis by C. S. Reddy, Tata McGraw Hill
2. Elementary Structural Analysis by Wilbur & Norris, Mcgraw-Hill College
3. Structural Analysis L. S. Negi & R. S. Jangid, Tata McGraw Hill
4. Structural Analysis by R. C. Hibbeler, Pearson Education
Reference Books:
5. Structural Analysis by G. S. Pandit& S. P. Gupta, Tata McGraw Hill
6. Intermediate structure analysis by C K Wang Mc. Graw Hill</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	2	-	-	-	-	-	-	-
CO2	3	-	-	-	2	-	-	-	-	-	-	-
CO3	3	-	-	-	2	-	-	-	-	1	-	-
CO4	3	-	-	-	2	-	-	-	-	-	-	-
CO5	3	-	1	-	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES552	**Design of Steel Structures Sessional**	**PS**	**0**	**0**	**3**	**3**	**1.5**
Pre-requisite(s)		Course Assessment methods					
Solid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Apply knowledge of solid mechanics for design solutions. • CO2: Understand basic design philosophy applicable to steel structures. • CO3: Formulate, analyze, and designbasic components of Civil Engineering Steel structures.						
Topics Covered (Hrs)	**Introduction**, Properties of structural steel, I.S. rolled sections, I.S. specifications **(2)** **Design philosophy** of Limit State method for Steel Structures**(6)** **Design of Tension members**, Compression members in truss**(6)** **Design of Beams** (laterally supported /unsupported) : Simple beam using rolled sections, Built up sections /compound beams **(6)** **Design of Gantry girders(4)** **Design of Plate girders**, Connections, Stiffeners and curtailment of flange plates, Splicing – riveted and welded. **(2)** **Design of Simple Connections**: Riveted, Bolted and welded connections, moment resisting connections**. (6)** **Design of Struts and columns** including built-up columns under axial and eccentric loadings, Lacing and battens, Column splicing. **(6)** **Design of Column bases** – slab base, Gusseted base. **(4)**						
Text Books, and/or reference material(s)	***Text Books:*** 1. Design of steel Structures by N. Subrhamanium, Oxford publications 2. IS 800-2007: General Construction in Steel-Code of Practice 3. IS 808-1989: Dimensions of Hot Rolled Steel beam, column, channel and angle sections 4. www.nptel.iitm.ac.in/courses/ ***Reference Books:*** 5. Limit State Design of Steel Structures by S.K. Duggal, McGraw Hill publications 6. Limit State Design of Steel structures by VirendraGehlot&Dr. Ram Chandra, Scientific publisher 7. Design of steel Structures by S. S. Bhavikatti, IK Intl Publishing House, N Delhi						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES553	**Transportation Engineering& Soil Mechanics Lab**	**PS**	**0**	**0**	**3**	**3**	**1.5**
Pre-requisite(s)		Course Assessment methods					
Transportation&Foundation Engineering		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes (COs) :	• CO1: Achieve Knowledge of Design and development of experimental skills. • CO2: Understand the principles of design of experiments on materials • CO3: Understand the principles of design of experiments on soil
Topics Covered (Hrs)	**A). Transportation Engineering** 1. Aggregate grading analysis. 2. Determination of flakiness index. 3. Determination of aggregate impact value. 4. Aggregate crushing value test. 5. Determination of softening point. 6. Determination of penetration value. 7. Ductility test. 8. Determination of consistency properties of soil **B). Engineering Foundation** 1).Determination of specific gravity of soil 2). Mechanical analysis of soil (Fine fraction- Hydrometer method) 3). Mechanical analysis of soil (Sieve analysis) 4). Light compaction test (Proctor test) 5). Direct shear test 6). Los Angeles abrasion test.
Text Books, and/or reference material(s)	***Text Books:*** 1. Highway Engineering by S. K. Khanna, C.E.G. Justo and A. Veeraraghavan, Nemchand& Bros. 2. Engineering Soil Testing by Shamsher Prakash, (1979), Nemichand, New Delhi 3. Soil Tsting for Engineers by William Lambe, (2003), MIT. ***Reference Books:*** 4. Relevant IRC/IS codes. 5. Engineering Properties of soil and their measurements by Joesph E Bowles, McGraw hill 6. Geotechnical Laboratory Measurements by John T. Germaine, Amy V. Germaine, (2009), John Wiely

Mapping of Course Outcomes Cos→Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	3	1	-	-	-	-	-	-	-
CO3	-	-	-	3	1	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES554	**Surveying laboratory and Estimation sessional**	**PCR**	**1**	**0**	**3**	**4**	**2.5**
Pre-requisites:		Course Assessment methods:					
CEC 303 & CEC403		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes	• CO1: learn the basic surveying techniques and the use of basic surveying instruments. • CO2: learn the art of quantity estimation, preparation of Bill of Quantities, and writing specification. • CO3: Learn rate analysis
	A). Surveying Fieldwork 1). Chain Survey. 2). Compass traverse work. 3). Uses of dumpy level, Profile levelling and cross-sectioning.

Topics Covered	4). Plane table surveying work – using radiation and intersection methods. 5). Contouring by any method (Optional subject to availability of time). 6). Study of theodolite,function of its different parts, Measurement of horizontal and vertical angle **(7 laboratory classes)** **B). Estimation** Introduction to quantity surveying, Methods of measurement and units of measurement for various items of work, Procedures of computation, Use of proforma. **(2)** Types of estimates, Data required for estimation. **(2)** Preparing detailed estimates for various types of Civil Engineering works. **(7) + 5 sessional classes)** Specifications of different items of work. **(1 hr. theory class lectures)** Analysis of rates of different items of work, Schedule of rates, Cost of works, Overhead charges, Contingencies, Contractors' profit margin etc. **(2 + 1 sessional)** Practical work on estimation as assigned by the teacher. Total: (**14 hrs of theory classes + 7 sessional classes)**
Text Books, and/or reference material	***Text Books:*** 1. Surveying and Levelling Part I by T. P. Kanetkar, and S. V. Kulkarni, Pune VidyarthiGrihaPrakashan Pune – 30, 1979, 2. Engineering Materials by S. C. RangwalaCharotar Pub. House, Anand, 3. Building Construction by S. C. Rangwala, Charotar Pub. House, Anand, 4. Estimating and costing in civil engineering – theory and practice, 23rd edition by B. N. Dutta, UBPSD, New Delhi, 1991. 5. Estimating, costing and specification in civil engineering, 6th edition by M. Chakraborty, Kolkata, 1979. ***Reference Books:*** 6. Text book of estimating and costing (civil engineering) by G. S. Birdie, Dhanpat Rai & Sons, Delhi, 1986. 7. Civil engineering Contracts and Estimates by B. S. Patil, Orient Longman, New Delhi, 1981.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	-	-	3	-
CO2	-	-	-	-	-	-	-	-	-	-	3	-
CO3	-	-	-	-	-	-	-	-	-	-	3	-

SIXTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC601	**Water Resource Engineering**	**PCR**	**3**	**1**	**0**	**4**	**4**
Pre-requisite(s)		Course Assessment methods					
Fluid mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs):	• CO1: Understanding of occurrence, distribution, storage & transmission of water in different form in the space, on the surface and below the surface of the earth. • CO2: Understanding of tempo-spatial collection of data and preparation of hydro-meteorological information system. • CO3: learning importance, requirement, method & infrastructure for imparting irrigation water to crop, development & conservation of water for its economic & efficient use						
Topics Covered (Hrs)	**Hydrology:** Hydrologic cycle&system model, Hydro-meteorological Information Systemand its Definition, need, generation, maintenance, validation, calibration of data sets, estimation of missing data, retrieval of data **(5)** **Precipitation:** Forms, types&measurement, Recording & non-recording gauges, Network, Analysis& Adjustment of data, Average depth, depth-area-duration analysis, Surface retention, Detention, Overland flow, Interception, Depression storage**.(6)** **Evaporation & Transpiration**: Factors, Measurement, formula consumptive use **(2)** **Stream flow:**Stage, discharge&relations, interpretation of stream flow records. Factors affecting the run off, yield, flow duration & mass curve **(4)** **Infiltration**: Process, Capacity, Measurement, Estimation **(3)** **Run-off:** Factors, Yield, Flow-duration curve, Flow mass curve. **(3)** **Hydrograph**: Base flow separation, Unit hydrograph, Synthetic hydrograph **(3)** **Irrigation:**Necessity, Advantages, Disadvantages, Types, Water distribution techniques, Quality of water, Duty, Delta, Base period, Indian crop seasons, Irrigation efficiencies, Soil-moisture – irrigation relationships, Estimating depth and frequency of irrigation. **(5)** **Canal irrigation system:**Capacities, losses, Design & construction of unlined, lined & stable channels,Sediment transport, Economics of canal lining, Cross drainage works**(3)** **Water-logging and control**: Causes, Control, Reclamation of saline and alkaline lands, Surface & Sub-surface drainage **(3)** **Diversion head-works:** Definition of weirs, barrages & their classification, Layout of typical diversion head-works & function of its components. **(2)** **Reservoirs:**Types,selection of site, Storage zones, Fixation of capacity, regulation.**(3)** **Dam:**Earthen and concrete dam, selection criteria,design**(4)** **Spillways and energy dissipaters:** Location, types, energy dissipation, stilling basin & spillway gate **(4)** **Flood Forecasting:** Estimation, forecasting & mitigation, flood land management **(4)** **Flood routing:** Reservoir & Channel routing (hydrological method only) **(2)**						
Text Books, and/or reference material(s)	***Text Books:*** 1. Engineering Hydrology by K. Subramanya, Fourth Edition, McGraw Hills Education (India) 2.Irrigation Engineering and Hydraulic Structures by S. K. Garg, Khanna Publishers, New Delhi ***Reference Books:*** 3.Irrigation and Water Power Engineering by B. C. Punmia, B. B. Pande, A. K. Jain, A. Kumar,, 16th Edition, Laxmi Publications (P) Limited, New Delhi						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3		3		-	3	-	-	-	-	-
CO3	-	-	3	-	3	3	-	3	3	2	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEC602	**Foundation Engineering**	**PCR**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Soil Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: Calculate shear strength of soil
- CO2: Determine the earth pressures on foundations and retaining structures
- CO3: Analyse stability of finite and infinite soil & rock slopes
- CO4: Calculate the bearing capacity of soils and foundation settlements

Topics Covered (Hrs)

Shear strength of soil: Determination of shear strength in laboratory and in field, Mohr-Coulomb failure criterion, Failure envelopes and shear strength parameters for different test conditions, Problem. **(6)**

Lateral earth pressure theories: Analytical and graphical methods, Effect of surcharge, water table and stratification on earth pressure, Design of cantilever sheet pile, Problem. **(8)Stability of slopes**, infinite slopes, Analysis of finite slopes by method of slices, modified method of slices, friction circle method, Taylor's stability number, Effect of pore water pressure, Problem **(8)**

Bearing capacity of shallow foundations: Selection of location and depth, Analytical method of using Terzaghi's equation, I.S. method, Skempton's equation, Field test method, Method based on SPT, Design of combined footings. **(8)**

Bearing capacity of pile foundation: Types of piles, Bearing capacity of single and group of piles, Problem. **(6)**

Well foundation: Elements of wells, Types. **(2)**

Text Books, and/or reference material(s)

Text Books:

1. Geotechnical Engineering: Principal and Practices of Soil Mechanics and foundation Engineering by V N S Murthy.
2. Basic and Applied Soil Mechanics by G.Ranjan and A.S.Rao

Reference Books:

3. Foundation analysis and Design by J.E.Bowles
4. Soil Mechanics and Foundation Engineering by S.K. Garg, Khanna Publishers
5. Advanced Soil Mechanics by B.M. Das, McGraw Hills Publishers

Mapping of Course Outcomes COs→

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	1	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	1	-	-
CO3	2	3	2	-	-	-	-	-	-	-	-	-
CO4	3	2	-	1	-	-	-	-	-	-	-	-

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEC603</td><td>Environmental Engineering</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">None</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Apply knowledge of water supply & wastewater engineering for design solutions.
• CO2: Understand basic design philosophies applicable to conveyance and treatment units of water & wastewater.
• CO3: Formulate, analyze, and design basic components of water supply & wastewater disposal.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Water – uses & requirement: Sources, Quantity, Quality criteria, Intakes & transportation. (9)
Conventional water treatment methods: Aeration, Sedimentation, Coagulation & flocculation, Filtration, Disinfection – including design of units. Other miscellaneous water treatment processes. (13)
Water storage & distribution systems, Design of pipe networks. (3)
Introduction to plumbing systems in buildings. (2)
Estimation of quantities of sanitary wastewater & storm water runoff. (3)
Sewerage system, Design of sewers, Sewer appurtenances, Materials of sewer construction. (5)
Quality & characterisation of domestic wastewater: different parameters including oxygen demands, Standards of sewage disposal. (4)
Principles of wastewater treatment, Physical, chemical & biological treatment methods, Primary & secondary treatment, Bio-filter, Activated sludge process, Stabilisation pond, Septic tank. (12)
Introduction to other treatment processes including digestion & disposal of sludge.(3)
Principles of stream sanitation. (2)</td></tr>
<tr><td>Text Books, and/or reference material (s)</td><td colspan="7">Text Book:
1. Environmental Engineering (Vol. I & II) by Punmia, Jain & Jain, Laxmi Publications (P) Ltd, New Delhi
2. Environmental Engineering (Vol. I & II) by S. K. Garg, Khanna Publishers, Delhi
Reference Book:
3. Environmental Engineering by H.S. Peavy, D. R. Rowe & G. Tchobanoglous, McGraw Hill Education (India) Private Limited, New Delhi
4. Wastewater Engineering, Treatment & Reuse (4th Ed) by Metcalf & Eddy, Inc. (Revised by G. Tchobanoglous, F. L. Burton & H. D. Stensel, Tata McGraw Hill Education Private Limited, New Delhi</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CES651</td><td>Environmental Engineering Laboratory & Computational Laboratory- I</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisite(s)</td><td colspan="5">Course Assessment methods</td></tr>
<tr><td colspan="3">Environmental Engineering</td><td colspan="5">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Achieve Knowledge of design & development of experimental skills
• CO2: Understand the principles of design of experiments.
• CO3: To learn step by step procedure for modelling technique & analysis of civil engineering problems by finite element based software
• CO4:Analyse & solve for forces and deflection in trusses, beams and frames under static loading
• CO5: Analyse & solve for responses in trusses, beams and frames under dynamic loading</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">A). Environmental Engineering
1. pH and temperature.
2. Turbidity.
3. Conductivity.
4. Total solids, Settle able solids and suspended solids.
5. Chloride.
6. Acidity.
7. Alkalinity.
8. Residual chlorine.
9. Dissolved oxygen.
10. Colony count of bacteria.
B). Computational Laboratory- I
Introduction of computer aided design and drafting, Solution of structural problems using commercial software</td></tr>
<tr><td>Text Books, and/or reference material (s)</td><td colspan="7">Text Book:
1. Chemistry for Environmental Engineering and Science, 5th edition by C. N Sawyer, P. L.McCarty and G.F. Perkin, McGraw-Hill Inc., 2002
2. Numerical Methods for Scientists and Engineers byR. W. Hamming, Dover Publications
Reference Book:
3. Standard methods for the examination of water and wastewater. (2012). 21st Edition, Washington: APHA.
4. Applied Numerical Methods for Engineers Using Matlab and C byRobert J. Schilling, Sandra L. Harris, Nelson Engineering; Har/Cdr edition</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	1	-	3	-	-	-
CO2	-	-	-	3	1	-	-	-	-	-	-	-
CO3	2	-	3	-	2	-	-	-	-	-	-	-
CO4	3	-	3	-	3	-	-	-	-	1	-	1
CO5	3	-	3	-	3	-	1	-	-	-	-	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES652	**Concrete Technology Laboratory**	**PS**	**0**	**0**	**3**	**3**	**1.5**

Pre-requisite(s)	Course Assessment methods
Building Construction & Concrete Technology	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs)	• CO1: Conduct experiments for determining the properties of different engineering materials like cement, fine &coarse aggregates, concrete etc. and work in a group. • CO2: Design concrete mix proportion based on the properties of concrete ingredients. • CO3: Use modern instruments & tools for conducting the experiment on different engineering materials. • CO4: Prepare the report on experimental results.
Topics Covered (Hrs)	To determine the (a) fineness of cement by sieving, (b) standard consistency of cement and (c) setting time of cement. **(6)** To determine the (a) specific gravity of cement (b) compressive strength of cement and (c) soundness of cement. **(6)** To determine the (a) particle size distribution, (b) specific gravity and water absorption and (c) bulk density and voids in coarse aggregate**. (6)** To determine the (a) particle size distribution, (b) specific gravity and water absorption and (c) bulk density and voids in fine aggregate. **(6)** Concrete mix design by I.S Method**. (6)** (a) Preparation of concrete specimens to determine the compressive strength flexural strength and split tensile strength of concrete of a given mix proportions.**(6)** (i) Compressive strength at 07 days - 3 nos cube + 3 nos cylinder (ii) Compressive strength at 28 days - 3 nos cube + 3 nos cylinder (iii) Split tensile strength at 28 days - 3 nos cylinder (iv) Flexural strength at 28 days - 3 nos prism (b) Test above specimen according to the proper testing day (7 days and 28 days) **(3)** (c) To determine the consistency and workability of freshly mixed concrete by i) Slump test and ii) Compacting factor test
Text Books, and/or reference material(s)	***Text Books:*** 1. Concrete Technology by A. M. Nevilleand J. J. Brooks, Pearson Edu. Publication. 2. Concrete Technology by M. S. Shetty, S. Chand Publication. ***Reference Books:*** 3. Concrete Technology by M. L. Gambhir, Tata McGraw Hill. 4. IS code of practice: 383-2016, 10262-2019, 456-2000 etc.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	3	-	-	-	-	2	-	-	-
CO2	-	-	3	2	-	-	-	-	2	-	-	-
CO3	-	-	-	2	3	-	-	-	1	-	-	-
CO4	-	-	2	1	-				1	2		

<table>
<tr><td colspan="9">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSC631</td><td>Economics and Management Accountancy</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
</table>

Course Outcomes

- To review basic economic principles with students;
- To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works;
- To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.

Topics Covered

PART 1: Economics

Group A: Microeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Economics: Basic Concepts	2	0	0	2	2
Unit 2:	Theory of Consumer Behaviour	3	0	0	3	3
Unit 3:	Theory of Production, Cost and Firms	3	0	0	3	3
Unit 4:	Analyses of Market Structures: Perfect Competition	3	0	0	3	3
Unit 5:	Monopoly Market	2	0	0	2	2
Unit 6:	General Equilibrium & Welfare Economics	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

Group B: Macroeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Macroeconomic Theory	2	0	0	2	2
Unit 2:	National Income Accounting	3	0	0	3	3
Unit 3:	Determination of Equilibrium Level of Income	4	0	0	4	4
Unit 4:	Money, Interest and Income	2	0	0	2	2
Unit 5:	Inflation and Unemployment	2	0	0	2	2
Unit 6:	Output, Price and Employment	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

PART 2: Accountancy

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Accounting	3	0	0	3	3
Unit 2:	Financial Statement Preparation and Analysis	5	0	0	5	5
Unit 3:	Financial Ratio Analysis	4	0	0	4	4
	TOTAL	**12**	**0**	**0**	**12**	**12**

Text Books, and/or reference material

PART 1: Economics

Group A: Microeconomics

1. Koutsoyiannis: Modern Microeconomics
2. Maddala and Miller: Microeconomics
3. AnindyaSen: Microeconomics: Theory and Applications

	4. Pindyck&Rubenfeld: Microeconomics **Group B: Microeconomics** 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. SoumyenSikder: Principles of Macroeconomics **PART 2: Accountancy** 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

CO-PO MAPPING of Economics and Management Accountancy (HSC631)

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	3	3	3

SEVENTH SEMESTER

Department of Management Studies								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1:To make budding engineers aware of various management functions required for any organization • CO2:To impart knowledge on various tools and techniques applied by the executives of an organization • CO3:To make potential engineers aware of managerial function so that it would help for their professional career • CO4:To impart knowledge on organizational activities operational and strategic both in nature • C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science
Topics Covered	**UNIT I:** Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter's five forces, Management functions – overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization**(8)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7) **UNIT III:** Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8) **UNIT V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)
Text Books, and/or reference material	<u>Suggested Text Books</u>: 1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. 2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education 4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 5. Operations Management, 7th edition (Quality control, Forecasting), Buffa&Sarin, Willey <u>Suggested Reference Books:</u>

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	2	2	
CO2				2					2	2		
CO3				2					3	2		
CO4							1		3			
CO5				2					2	2	2	

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CES752	**Structural Engineering & Computational Lab-II**	**PS**	**0**	**0**	**3**	**3**	**1.5**

Pre-requisite(s)	Course Assessment methods
Design of Concrete Structuresalong with Concrete Technology Laboratory	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: Design concrete mix proportion based on the properties of concrete ingredients and design and detailing of reinforced concrete beam under given conditions and work in a group.
- CO2: Use modern instruments and tools for experimenting on different engineering materials in a group.
- CO3: Prepare the report on experimental results.
- CO4: Ability to apply computational software to analyse and design of different civil engineering problems and apply in industries

Topics Covered (Hrs)

1. Concrete mix design for different grades of concrete (as per Indian Standard guidelines).
2. Design, detailing and bar bending schedule for R.C. beam under given conditions.
3. Casting and study on the strength and deflection behavior of R.C. beams.
4. Application of commercial software for solving Civil Engineering problems

Text Books, and/or reference material(s)

Text Books:

1. Limit State Design of Reinforced Concrete by P. C. Varghese, Prentice Hall, Inc.
2. Concrete Technology by M. S. Shetty, S. Chand Publication.
3. Concrete Technology y M. L. Gambhir, Tata McGraw Hill.
4. IS code of practice: 383-2016, 10262-2019, 456-2000 etc.

Reference Books:

5. Manuals of Commercial /Open source software related to Civil Engineering Applications (Eg. SAP, STAAD, ABAQUS,ETAB, LS DYNA, Plaxis, Geomedia, ERDAS …etc)

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	3	3	-	-	-	-	2	-	-	-
CO2	-	-	3	2	3	-	-	-	2	-	-	-
CO3	-	-	2	1	-	-	-	-	1	2	-	-
CO4	-	1	2	-	3	-	-	-	-	-	-	-

DEPTH ELECTIVES OFFER BY CE DEPARTMENT

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE610	**Advanced Design of Concrete Structures**	**PCL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Design of Concrete Structures		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs)	• CO1: Acquire knowledge of engineering design of different Member • CO2: Ability to analyze the Utility Structures: Bunker, Silo, Water Tank, Shell etc • CO4: Ability for understanding the need of future studies						
Topics Covered (Hrs)	**Combined footing:** Types, design of rectangular slab, trapezoidal, strip and raft type **(6)** **Portal and multi-storied building frame:** Design of continuous beam, earthquake resistance design & detailing, codal provisions **(6)** **Bunkers&silo:**Analysis& Design bunker & silo **(6)** **Shell and folded plate:** Design of shell and folded plate **(4)** **Serviceability Limit State:** Deflection and cracking **(4)** **Deep and curve Beam:** Design of deep & curve beam **(4)** **Tension Members:**Design under axial, bending and combination of both**(4)** **Flat Slab:** Design of flat slab and associated Column **(4)** **Water Tanks:** Different types tank **(6)**						
Text Books, and/or reference material (s)	***Text Books:*** 1. Ad. R. C. C Design Vol-II, by S.S. Bhavikatti, New Age International (P) Limited, New Delhi 2. Ad. R. C. C Design, by N.K. Raju, CBS Publishers & Distributor, New Delhi 3. IS 456: 2000, Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi. 4. IS 3370 (I, II, IV): 2009 & 1965, Concrete structures for storage of Liquids- Code of practice (1stRevision), BIS, New Delhi. 5. IS 1893 (I): 2016, Criteria for earthquake resistance design of Structures-General provisions and building (6thRevision), BIS, New Delhi. 6. IS 13920: 2016, Ductile design & detailing of R. C. structures subjected to seismic forces- code of practice (1st Revision), BIS, New Delhi 7. www.nptel.ac.in ***Reference Books:*** 8. Reinforced Concrete, 6th Edition, by S.K. Mallick and A.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, 1996. 9. Reinforced Concrete Design, 2nd Edition, by S. Unnikrishna Pillai and DevdasMenon, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	1
CO2	-	-	3	-	2	-	1	-	-	-	-	1
CO3	-	-	-	-	-	-	-	-	-	-	-	3

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEE611</td><td>Advanced Structural Analysis</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisite(s)</td><td colspan="5">Course Assessment methods</td></tr>
<tr><td colspan="3">Engineering &Solids Mechanics with Structural Analysis</td><td colspan="5">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Develop basic understanding of the fundamental concepts and theorems of the advanced topics in analysis of structures.
• CO2: Model and analyze different structural systems by matrix method of analysis using element approach of force/ flexibility method.
• CO3: Model and analyze different structural systems by matrix method of analysis using element approach of displacement/ stiffness method.
• CO4: Understand the basic methodology adopted in developing computer programmes for structural analysis and thus, develop an overall understanding of the available structural analysis softwares.
• CO5: Ability to write the governing equations for stability&analysis of structures.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Recapitulation of basic concepts of structural analysis, force & displacement methods, statical& kinematic indeterminacies of pure truss, pure frame & generalized structures(2)
Stiffness/ Displacement Method: System approach of solution, global and local coordinate systems, element stiffness matrices for truss and frame elements, displacement and force transformation matrices, connectivity arrays, global stiffness matrix, global load vector, assembling of stiffness matrix and load vector, solution of stiffness equation, output of global displacements and local member end forces, introduction to warping torsion and shear deformation, three dimensional element stiffness matrix and transformation matrix, analysis of grids, different types of example problems. (10)
Flexibility/ Force Method: System approach of solution, global and local coordinate systems, element flexibility matrices for truss and frame elements, force transformation matrices, global flexibility matrix, global load vector, assembling of flexibility matrix, solution of flexibility equation, output of displacements and member end forces, different types of example problems. (8)
Elastic Stability Analysis of beam, column and frames. (10)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Structural Analysis by L.S. Negi & R.S. Jangid, Tata McGraw-Hill Publishing Company Limited
2. Structural Analysis: A Unified Classical and Matrix Approach, Amin Ghali, Adam M. Neville by E& FN SPON 4th Ed.
3. Stability Analysis and Design of Structureby M. L. Gambhir, Springer 2004 edition
Reference Books:
4. Structural Analysis: A Matrix Approachby G.S. Pandit& S.P. Gupta, Tata McGraw-Hill Publishing Company Limited</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	1	-	-	-	-	-	-	-
CO3	3	3	3	1	1	-	-	-	-	-	-	1
CO4	-	-	-	-	2	-	-	-	-	-	1	2
CO5	3	3	2	1	-	-	-	-	-	-	-	1

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEE612</td><td>Mechanics of Composite Structures</td><td>Program Elective (PEL)</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">Knowledge of Solid Mechanics, Structural Analysis & Design</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Development of skills of finding out mechanical properties of composite materials as well as predicting structural behaviour of composites under different loads.
• CO2: Knowledge of basics of analysis and design of structural components, made of variety of composite materials.
• CO3: Knowledge of using numerical tools for modeling and analysis of simple structural components</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Introduction, Types of composite materials, Lamina and Laminate, Matrix and Fibre, Fibre-reinforced Composites, Comparison of strengths between bulk material and fibres. (6)
Co-ordinate systems, Effect of orientation of fibres on the strength and stiffness of Composites. (6)
Brief outline of manufacturing processes. (4)
Micromechanics and Macro mechanics, Constitutive relations, Stresses and Strains, Failure criteria of composites. (8)
Analysis of Composites: beams and plates (12)
Finite Element Method in analysis of Composite Structures (6)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Mechanics of Composite Materials by Robert M. Jones, Taylor and Francis (2015)
2. Mechanics of Composite Structures by Autar K. Kaw, Taylor and Francis (2006)
Reference Books:
3. Mechanics of Composite Materials and Structures by MadhujitMukhopadhyay, University Press (2004)</td></tr>
</table>

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	-	-	-	-	-	-	-	-	-
CO3	-	2	-	-	3	-	-	-	-	-	-	-

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEE613</td><td>Material Technology</td><td>Program Elective (PEL)</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">Engineering Mechanics and Mathematics</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
</table>

Course Outcomes (COs) :	• CO1: Development of skills for predicting structural behaviour of different materials under different loads • CO2: Knowledge of basics of analysis and design of structural components, made of variety of materials • CO3: Developing the requisite skill that helps in studying the advanced courses related to Structural Analysis, Design of Structures
Topics Covered (Hrs)	**Material and Material Defects**: Metallic materials, Polymeric Materials, Ceramics and Composites, elastic and plastic deformation, Mechanism of deformation and its significance in design and shaping **(8)** **Failure mechanisms of Materials**:**Fracture:** Definition and types of facture, Brittle fracture: Critical stress and crack propagation velocity for brittle fracture. Ductile fracture: Notch effect on fracture. Fracture toughness. Ductility transition. Definition and signification. Conditions of ductility transition factors affecting it. **(6)** **Fatigue Failure:** Definition of fatigue and significance of cyclic stress. Mechanism of fatigue and theories of fatigue failure, Fatigue testing. Test data presentation and statistical evolution. S-N Curve and its interpretation. Influence of important factors on fatigue. Notch effect, surface effect, Effect of pre-stressing, corrosion fatigue, Thermal fatigue. **(5)** **Creep:** Definition and significance of creep. Effect of temperature and creep on mechanical behaviors of materials. Creep testing and data presentation. **(6)** **Introduction to New Materials**: **Composites:** Basic concepts of composites, Processing of composites, advantages over metallic materials, various types of composites and their applications. Nano Materials: Introduction, Concepts, synthesis of nano materials, examples, applications and nano-composites. Polymers: Basic concepts, Processing methods, advantages and disadvantages over metallic materials, examples and applications. **(10)** **Strength Analysis of materials under different loading:** Stress, strain due to normal, shear, flexure, impact, torsion loads. Analysis by energy method. **(7)**
Text Books, and/or reference material(s)	***Text Books:*** 1. A Text Book of Strength of Materials by Ghosh &Datta, 2ed, New Age International Publication Pvt. Ltd, New Delhi 2. Engineering Materials Technology by W. Bolton, 3ed,Taylor & Francis Ltd ***Reference Books:*** 3. Engineering Materials: An Introduction to Properties, Applications and Design by David R.H. Jones, Michael F. Ashby, 4ed, Elsevier (BH)

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE614	**Applied Numerical Methods**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering Mathematics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	• CO1: Assess the error involved in a numerical method • CO2: Solve problems in engineering and science with a required accuracy using appropriate						

(COs) :	numerical methods • CO3:Write algorithm for the numerical methods for efficient coding of program • CO4:Understand the mathematics concepts underlying the numerical methods
Topics Covered (Hrs)	**Fundamentals of numerical methods:** Need for Numerical methods in Civil Engineering, Sources of Errors, Absolute, Relative and Percentage, round off error, and stability of algorithms. **(04)** **Linear system of algebraic equations:** Gauss elimination method, LU decomposition method; iterative methods, ill conditioned systems. Jacobi, Gauss Seidel method, Relaxation method. **(08)** **Nonlinear equations:** Bisection method, Regula Falsi method, Newton Raphson method, Modified Newton-Raphson method, Higher order Newton's method Bairstow method, system of non-linear equations. **(8)** **Interpolation and approximation**: Newton's, Lagrange and Hermite interpolating polynomials, cubic splines; least square and minimax approximations.(06) **Numerical differentiation and integration:** Newton-Cotes and Gaussian type quadrature methods. **(06)** **Ordinary differential equations:** Initial value problems: single step and multistep methods, stability and their convergence. Boundary value problems: functional approximation, finite difference method.**(08)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Numerical Methods for Scientists and Engineers byR. W. Hamming, Dover Publications; 2 edition 2. Numerical Methods: Problems and Solutions byMahinder Kumar Jain (Author), S.R.K. Iyengar (Author), R. K. Jain, New age publishers 3. Numerical Methods for Engineers by Chapra, S. C., and Canale, R. P., McGraw Hill, Inc., 2007. ***Reference Books:*** 4. Applied Numerical Methods for Engineers Using Matlab and C by Robert J. Schilling (Author), Sandra L. Harris, Nelson Engineering; Har/Cdr edition 5. Numerical Analysis for Scientists and Engineers: Theory and C Programs by Madhumangal Pal, Alpha Science Intl Ltd; 1 edition

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	3	-	3	-	-	-	-	-	-	-
CO3	3	-	3	-	3	-	-	-	-	1	-	-
CO4	2	-	-	-	3	-	1	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE615	**Bridge Engineering**	**PCL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)			Course Assessment methods				
Survey, Water Resource Engineering,analysis and design of structures			Continuous (CT) and end assessment (EA). CT+EA				
Course Outcomes	• CO1: Acquire knowledge to select different type bridges by assessing their material, capacity, quality & suitability						

(COs)	• CO2: Ability to make a bridge plan and design following requisite criteria • CO3: Supervise the construction procedure of different components of a bridge • CO4: Assess the quality and roles of various components of bridge
Topics Covered (Hrs)	**Hydraulic design:**Survey,Catchment, Site selection, Hydraulic geometry, Linear waterways, Economic span, Afflux and Scour. **(4)** **Loads onbridge:** Different types of load acting on bridge along with numerical**(6)** **Slab andboxculvert:**Analysis of deck slab - effective width & length method and numerical example with different type of live load. **(4)** **R.C. beam-slab and steel composite bridges:**R.C. T-beam bridgeand steel composite bridge design using Pigeaud's method and Courbon's method **(6)** **Dynamic response of bridge deck:** General features, factor affecting vibration, practical approach for vibration analysis and numerical examples.**(2)** **Prestressed concrete bridge:** General features, advantage of P.S.C. Bridge, design details of pre-tensioned and post–tensioned bridge and numerical (**6**) **Bridge bearing:** Introduction, types of bearing, design principles of different bearing and numerical examples **(4)** **Substructure:** Introduction, type of piers, forces acting on piers, stability analysis of abutment, types of wing wall and numerical examples of Pier and Abutment. **(4)** **Bridge foundation:** General aspect, types of foundations, design aspect of pile and well foundations and numerical examples of pile and well foundations.(**4**)
Text Books, and/or reference material(s)	***Text Books:*** 1. Bridge Engineering by S. Ponnuswamy, Tata McGraw-Hill Publishing Company Limited, New Delhi. 2. IRC:6-2017 Standard Specifications and Code of Practice for Road Bridges 3. www.nptel.ac.in ***Reference Books:*** 4. Design and construction of Highway Bridges by K. S. Rakshit, New Central Book Agency (P) Ltd

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	-	3	-	1	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	3	2	-	1
CO4	-	-	-	-	-	-	-	-	-	-	-	3

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE620	**Analysis and Design of Pavements**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Transportation Engineering		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO 1: Understanding of material characteristics for transfer of load • CO 2: Understanding of mechanics of transfer of vehicular load to pavement • CO 3: Development of ability to understand vehicle pavement interaction • CO 4: Ability to determine stresses in different type of pavements • CO 5: Development of expertise in design of pavement of different types of roads, highway, airport pavement						

Topics Covered (Hrs)	**Characterization of Sub-Grade Soil and Mineral Aggregates:** Introduction, particle size analysis, gradation, moisture content, consistency, test, classification, composition, compaction, strength determination, strength properties of mineral aggregates**(8)** **Bituminous Materials:** Introduction, desirable properties, tests, other binders, engineering properties and mix design **(8)** **Design of Cement Concrete Mixes for Pavements:** Introduction, cement, properties, mineral aggregates, water, admixtures, properties of fresh concrete, test on hardened concrete, factors for durability, design of cement by BS (10262), IRC (44), Dry Lean Cement Concrete (MORTH 201), Mix Design for Rural Roads (IRC :SP:62) **(8)** **Factors Affecting Pavement Design:** Types of pavements, factors affecting design of pavements**(4)** **Analysis and Design of Flexible Pavements:** Stress analysis, design methods, benefits of M-E method, test roads**(4)** **Structural Evaluation of Pavements:** Purpose, types, and methods of structural evaluation, structural evaluation by static loading, steady – state Vibratory Loading, impulse lading, Models of Falling Weight Deflectometer, FWD, back calculation of Layer Moduli from FWD Test data, uses of Back-calculated Pavement Layer Moduli, Structural Evaluation of Rigid Pavement using FWD.**(6)** **Structural Evaluation of Unbound Granular and Sub-Grade Layers:** Using Dynamic Cone Penetrometer (DCP) – Development of DCP Test, The Dynamic Cone Penetrometer, material testing with DCP, determination of DCP index values, factors affecting DCP test results, correlation of DCP index values with other standard test values, application of DCP test data, limitation of DCP**(6)**
Text Books and/or reference material(s)	***Text Books:*** 1. Highway Engineering by R. Srinivas Kumar. ***Reference Books:*** 2. Principles of Pavement Engineering by Nick Tom

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	3	-	-
CO2	-	-	3	4	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	-	-	-	2	-	-	-
CO4	3	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	3	-	-	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE621	**Finite Element Method**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Solid Mechanics, Structural Engineering &Engg. Mathematics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Understanding the advantage of FEM over classical methods and use it for modelling and analysis of real life engineering structures. • CO2: Skill to simulate simple engineering structures through FE modellling and interpret data from the FE analysis to ascertain their reliability and applicability in light of physical constraints of the system and common engineering sense. • CO3: Ability to use computational tools for solving Civil Engineering problems. • CO4: Skill of using advanced FEA software packages and development of FE codes for						

	modelling, analysis and investigation of problems related to industry and research.
Topics Covered (Hrs)	**Introduction**: Engineering Problems, Different numerical methods, History of Finite Element Method (FEM), Steps in FEM, Areas of Application, Verification problems, implementation of Engineering Problems in FEM. **(10)** **Solution of Engineering Problems using Matrix operation**: Importance, Matrix Manipulation Techniques, Solution of Simultaneous Linear Equations, Inverse of Matrix, Computer Implementation. **(6)** **Spring Element:** General, Implementation in FEM, Applications in civil engineering, Problems. **(6)** **Bar Elements**: Definition, Stiffness Matrix, Load vector and displacement vector, Implementation in FEM, Problems and Validation. **(6)** **FE Modelling of Engineering Problems:** Trusses, beams, Frames etc. **(14)** **Computer Programs**/ SOFTWARES based on FEM: Use in solution of Engineering Problems. **(3)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Finite element analysis: theory and programming by C S Krishnamurthy (2001): Tata McGraw Hill Education 2. An Introduction to the Finite Element Method by Reddy, J. N., 2005. 3. Fundamentals of Finite Element Analysis by David V. Hutton Publisher: Tata Mcgraw Hill Education Private Limited (2005) ***Reference Books:*** 4. Finite Element Procedures by Klaus-Jurgen Bathe Publisher: Prentice-Hall (2009)

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	2	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	-	2	-	3	-	-	-	-	-	-	-	-

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEE622</td><td>Ground Improvement</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">Soil Mechanics&Foundation Engineering</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: understand how to improve the geotechnical properties of soft soil by different techniques.
• CO2: identify ground conditions and suggest method of improvement
• CO3: understand the principles of soil reinforcement and confinement in engineering constructions.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Introduction: Formation of soil, major soil type, collapsible soil, expansive soil, ground improvements; objective, potential. (8)
Ground Improvement in Granular Soil: In place densification by (i) Vibrofloatation (ii) Compaction pile (iii) Vibro Compaction Piles (iv) Dynamic Compaction. (12)
Ground Improvement in Cohesive Soil: Preloading with and without vertical drains, Compressibility, vertical and radial consolidation, preloading methods. Types of Drains, Design of vertical Drains, construction techniques. Stone Column: Function Design principles, load carrying capacity, construction techniques, settlement of stone column foundation.(22)</td></tr>
</table>

Text Books, and/or reference material (s)	***Text Books:*** 1. Ground Improvement by M.P. Moseley and K. Krisch, (2006)–II edition, Taylor and Francis 2. Designing with Geosynthetics by Koerner, R. M (1994), Prentice Hall, New Jersey 3. Engineering Principles of Ground Modifications by Hausmann, M. R. (1990),McGraw Hill publications ***Reference Books:*** 4. Earth Reinforcement and soil structures by Jones C. J. F. P. (1985), Butterworths, London. 5. Ground Control and ImprovementbyXianthakos, Abreimson and Bruce 6. Ground Control and Improvement by K. Krisch&F.Krisch (2010), John Wiley & Sons, 1994. 7. Foundation Design principles and Practices by Donald P Coduto, 2nd edition, Pearson, Indian edition, 2012

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	3	-	2	-	-	-	-	-	-	-	-
CO2	-	2	3	2	-	-	1	-	-	-	-	-
CO3	-	3	2	-	-	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE623	**Remote Sensing and GIS**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
None		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes (COs) :	CO1: Learn about basic items, parameters & concepts related with remote sensing. CO2: Apply techniques of visual image interpretation and digital image processing. CO3: Use GIS and its components for basic applications in civil engineering.
Topics Covered (Hrs)	**Remote Sensing**: History, Physical basis, Electromagnetic spectrum, Spectral reflectance curves, Spectral signatures, Resolutions, Passive & active remote sensing, Remote sensing platforms. **(12)** **Sensors**: Different types, Satellite band designations & principal applications, FCC, Aerial photography & its interpretation. **(9)** **Digital image processing**: Pixels & DN values, Digital image formats, Image processing functions – Image enhancement, Image transformation, Image classification & analysis. **(10)** **Geographic Information System:** Introduction, GIS components – hardware, software & infrastructure, GIS data types, Data input & processing, DEM generation, Preparation of thematic map from RS data. **(6)** **Integration of RS & GIS techniques** and its applications in the field of Civil Engineering. (5)
Text Books, and/or reference material (s)	***Text Books:*** 1. Remote Sensing & GIS (2nd Ed.) by B. Bhatta (Oxford University Press, New Delhi) 2. Textbook of Remote Sensing & Geographical Information Systems (3rd Ed.) by M. Anji Reddy (BS Publications, Hyderabad) ***Reference Books:*** 3. Remote sensing &Image Interpretation (6th Ed.) by T.M. Lillesand, R.W. Kiefer & J.W. Chipman (Wiley India (P) Ltd., New Delhi) 4. Geographical Information Systems (2nd Ed.) by P.A. Longley, M.F. Goodchild, D.J. Maguire & D.W. Rhind (John Wiley & Sons, Inc.)

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	1	-	-	-
CO2	3	2	-	2	2	-	1	-	1	1	-	3
CO3	3	2	3	-	2	-	1	-	1	1	-	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE624	**Traffic Engineering and Management**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Transportation Engineering		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs):	• CO1: Apply knowledge of traffic study & analysis for design solutions. • CO2: Understand basic design philosophy applicable to traffic flow & highway intersections. • CO3: Formulate, analyze, and design basic components of highway intersections.						
Topics Covered (Hrs)	**Traffic characteristics**, Traffic engineering studies and analysis: Volume, speed, delay, origin and destination. (18) **Highway intersections**, Traffic flow theory, Traffic capacity, Traffic operations and control, Signal systems, Parking and terminal facilities, Traffic safety. (20) **Impact of highway traffic** on environment. (4)						
Text Books, and/or reference material(s)	***Text Books:*** 1. Traffic Engineering by R.P. Roess, W.R. McShane and E.S. Prassas, Prentice Hall. ***Reference Books:*** 2. Transportation Engineering and Planning, C.S. Papacostas, and P. D. Prevedouros, Prentice Hall India 3. Principles of Transportation Engineering, P. Chakroborty and A. Das, Prentice Hall India.						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE625	**Systems approach to Civil Engineering design**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	• CO1: Develop system approach based models of Civil Engineering systems. • CO2: Solve optimization problems. • CO3: Learn decision theory and its application to CE problems						
	Introduction: System concept for engineering design, System classification, system modeling, Methodology of system design.**(4)** **Optimization Techniques:**Linear Programming- Simplex Method Duality Theory, Dual Simplex,						

Topics Covered	Sensitivity analysus, Integer programming **(8)** **Network analysis:** Transportation problems, Assignment problems, Maximal flow, Project management **(8)** **Non-Linear programming:** Basic concept, Introduction to Lagrange multipliers, Kuhn-Tucker conditions **(4)** **Common Probabilistic models(8)** **Decision theory:** Decision problems, Decision criteria, Maximax, Equally likely, Minimax, Maximum likelihood, Bays' decision rule, Application to civil engineering systems design. **(10)**
Text Books, and/or reference material	***Text Books:*** 1. Engineering Hydrology by R. S. Varshney, Nem Chand & Bros. Roorkee (U.P.) 1986. 2. Operations Research by A. Ravindran, D. J. Philips, and J. J. Solberg, Principles and Practice 2nd Edition, John Weley& Sons, New York, 1987. 3. Engineering Optimization – Theory and Practice by S. S. Rao, 3rd Edition, New Age Int. (P) Ltd. Publishers, New Delhi, 2001. 4. Introduction to Operations Research – A computer oriented Algorithmic Approach by B. E. Gillett,TMH Edition, New Delhi 1985. ***Reference Books:*** 5. Nonlinear Programming – Theory and Algorithms by M. S. Bazaraa, & C. M. Shetty, John Wiley & Sons, New York, 1990. 6. Introduction to Optimum Design by J. S. Arora, McGraw Hill Int. Editions, McGraw Hill Book Co. Singapore, 1989. 7. Engineering Optimization – methods and Applications by G. V. Reklaitis, A. Ravindran,and K. M. Ragsdell, John Wiley & Sons, New York, 1983.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	3	3	-	-	-	-	2	2	-	-	-
CO2	-	3	3	-	-	-	1	-	-	3	-	2
CO3	-	3	3	-	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE710	**Structural Dynamics**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Develop &analyze damped & un-damped SDOF systems for free & forced vibration. • CO2: Develop and analyze the MDOF systems for free & forced vibration. • CO3: Model civil engineering structures & derive the dynamic properties of structures • CO4: Calculate natural frequencies, mode shapes& structural responses numerically • CO5: Apply the concepts & principles of structural dynamics for earthquake analysis of civil engineering structures & evaluate their seismic performance
Topics Covered (Hrs)	**Introduction:** D'Alembert's principle, dynamic loads, definition of degrees of freedom **(1)** **SDOF system:** Equations of motion, undamped and damped SDOF systems, viscous damping, critically damped, over-damped and under-damped system, damping coefficient determination, dynamic magnification factor and transmissibility. **(7)** **Forced vibration ofSDOF systems:** Vibrationunder sinusoidal loads, response to general dynamic loading - Duhamel's integral: impulse, rectangular, triangular loading problems. **(5)** **Fourier analysis and response in the frequency domain** theory, problems **(2)** **MDOF system:** Development and solution of equations of motion, problems **(2)**

	Free vibration ofMDOF systems: Eigen values and vectors, natural frequencies and modes, orthogonality of modes, normalization of modes, modal expansion, concept of normal/generalized coordinates, problems **(5)** **Free vibration response**: Free vibration of un-damped systems, modal analysis. **(3)** **Forced vibration of MDOF systems:** Modal expansion of excitation vector, modal analysis, modal contribution factors. **(3)** **Forced vibration response:**Modal analysis, forced vibration for un-damped systems subjected to sinusoidal loading and arbitrary loading**. (5)** **Damping in structures:** Classical, non-classical damping, mass proportional, stiffness proportional, Rayleigh, Caughey damping, Modal analysis for classically damped free and forced vibration systems **(4)** **Earthquake analysis of structures:** Equations of motion for un-damped and classically damped systems single and multiple degree of freedom systems, modal participation factors, modal analysis, response spectrum analysis, modal combination rules **(4)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Dynamics of Structures by Anil K. Chopra, PHI 2. Earthquake Resistant Design of structure by Pankaj Agarwal and Manish Shrikhande. 3. Structural Dynamics: Theory and Computation by Mario Paz, Kluwer Academic Publishers ***Reference Books:*** 4. Elements of Earthquake Engineering, Jai Krishna, A.R. Chandrasekaran, B. Chandra. South Asian Publishers. 5. Theory of Vibration with Applications, W.T. Thomson, PHI

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	-	-	-	-	-	-	-	-	-
CO2	2	3	3	-	-	-	-	-	-	-	-	-
CO3	3	2	2	-	1	-	-	-	-	-	-	2
CO4	3	3	3	3	2	-	-	-	-	-	1	2
CO5	3	2	-	2	1	1	-	1	-	-	1	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE711	**Advanced Design of Steel Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Design of Steel Structures		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Understand the design aspects, principles of few steel structures as a whole. • CO2: Apply basic knowledge of steel design of components for design solutions of whole structure. • CO3: Formulate, analyze, and design of various Civil Engineering Steel structures.						
Topics Covered (Hrs)	**Design of Industrial Shed**: Description of Different components, Loads Calculation, Analysis and Design of Truss members, Purlin, Top Chord and Bottom Chord Diagonals, Shoe Plate and Bolts design, Columns Design, Base Plate and Anchor Bolts Design. **(10)** **Design of water tank**:Staging, Columns braced type staging. **(10)** **Design of Castellated beams** and open web structures.**(4)** **Bridges:** Design loads for highway / railway bridges, Design of truss bridges for highway and railway**. (10)**						

	Introduction to Plastic Design: Plastic hinge, Plastic-Collapse method, Plastic Analysis of Frames **(8)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Design of steel Structures by N. Subrhamanium (Oxford publications) 2. IS 800-2007: General Construction in Steel-Code of Practice 3. IS 808-1989: Dimensions of Hot Rolled Steel beam, column, channel and angle sections 4. SP 6(1)-1964: Handbook for Structural Engineers. 5. IS 3370-1965 code for concrete structures for he storage of liquids 6. IS 805: 1968 Code of Practice for Use of Steel in Gravity Water Tanks 7. IRC:6-2017 Standard Specifications and Code of Practice for Road Bridges 8. www.nptel.iitm.ac.in/courses/ ***Reference Books:*** 9. Limit State Design of Steel Structures by S.K. Duggal (McGraw Hill publications) 10. Design of steel Structures by S. S. Bhavikatti (IK Intl Publishing House, N Delhi)

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	3	-	-	-	-	2	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	3	-	2
CO3	-	3	3	-	1	-	-	2	-	2	1	3

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE712	**Theory of Plates and Shells**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Solid Mechanics, Structural Analysis		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs):	• CO1: Derive the expressions of the curvature and displacement relationships of plates subjected to bending moments, twisting moments and shear force. • CO2:Analyse the simply supported plates and solve them by using Navier's and Levy's Methods. • CO3: Analyse the thin shell structures using membrane theory. • CO4: Design the cylinder shell and review the IS codal provisions of it.						
Topics Covered (Hrs	**Basic curvature and displacement relationships**. Expressions for bending, moment, twisting moments, shear forces. **(4)** **Plate equation**, Edge conditions. Solution of simply supported plates by Navier's and Levy's methods. Introduction to anisotropic plates. **(10)** **Plate subjected to in plane forces**, Buckling of plates. Numerical analysis of plates. Design of plates. **(6)** **Shell structures** Classification, Differential geometry, Curvature, Strain, Displacement relations. **(4)** **Membrane theory of thin shells** and design of cylindrical shells of double curvature (Synclastic and anticlastic), Shells of revolution, North light shell. **(10)** **Design of shell** and review of IS code provisions, Introduction to bending theories: Application to cylindrical shells and design.**(6)**						
Text Books,	***Text Book (s):*** 1. Theory of Plates and Shells by Timoshenko and Krieger, McGraw Hill 2. Theory and Analysis of Plates by Classic and Numerical Methods, Rudolph Szilard,						

and/or reference material(s)	Prentice Hall Inc. New Jersey ***Reference Book:*** 3. Design and Construction of Concrete Shell Roofs by G.S. Ramaswamy, CBS Publisher & Distributors (2005)

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	2	3	-	-	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-
CO4	-	1	3	-	-							

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE713	**Theory of Elasticity and Plasticity**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Engineering & Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	• CO1: To develop basic understanding of the behaviour of materials. • CO2: To define the stress and strain behaviour of structural elements. • CO3: To apply theory of elasticity in bending and torsion problems. • CO4: To apply theory of plasticity in failures of different materials and structures.
Topics Covered	**Stress & Strain**: Stress equilibrium equations, rectangular, cylindrical and spherical co-ordinates, Generalized Hooke's Law, Stress and strain compatibility equations. Plane stress and plane strain problems, Airy's stress function, Principal Stresses and strains, stress & strain invariants, numerical problems. **(15)** **Torsion**: Shafts of circular and non-circular prismatic sections, Saint Venant theory, warping function, stress function. **(7)** **Theories of Failure**: Basic concepts and Yield Criteria, Different Theories of Failure, Yield Locus and Yield Surfaces. Equations of Plasticity. **(8)** **Plasticity**: hydrostatic stresses, deviatoric stresses, invariants of deviatoric stresses, yield criteria, von Misses, Tresca yield criteria, theories of plastic flow, plane stress, plane strain problems in plasticity, thick cylinders, thick spheres. **(12)**
Text Books, and/or reference material	***Text Books:*** 1. Theory of Elasticity and Plasticity by S. Timoshenko, MC Graw Hill Book company. 2. Theory of Elasticity and Plasticity by Sadhu Singh, Khanna Publishers. ***Reference Books:*** 3. Advanced Strength of materials by Papov, MC Graw Hill Book Company. 4. Plasticity for structural Engineers by Chen, W.F. and Han, D.J, Springer-Verlag, New York.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE714	**Structural Health Monitoring**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Knowledge of Solid Mechanics and Structural Design	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Knowledge of assessment and monitoring of existing structures as well as for newly constructed structures. • CO2: Exposure and skill to use relevant NDT equipment for research and industrial applications. • CO3: Knowledge on instrumentations in structures, their use and interpret the collected data from instrumentations. • CO4: Based on the above, the students are expected to suggest remedial measures for distressed structures.
Topics Covered (Hrs)	**Preamble:** Definition of structure, different types of structures, behaviour of structures under variety of loading conditions, deterioration and failure of structures, structural materials. **(4)** **Introduction:** What is structural health and SHM, importance, application and present scenario of SHM in India and abroad, parameter related to structural health. **(4)** **Types of SHM:** Periodic and continuous, methods for implementation of each. **(6)** **Measurement techniques**: Destructive and non-destructive **(6)** **Equipment:** For non-destructive testing, working principles of this equipment and use **(8)** **Health monitoring in dynamic condition:** Basics of structural dynamics, sensing technologies, data collection and analysis, basic concept of signal processing, identification of structural health using modal parameters. **(14)** **Field visit:** Visitto the site(s) of old structure(s) for assessing their existing condition for SHM purpose. **(3)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Structural Health Monitoring by Victor Giurgiutiu 2. New trends in Structural Health Monitoring by Ostachowich, Witslaw, Guemes, Alfredo. 3. Dynamics of structures by A K Chopra, Pearson/Prentice Hall. ***Reference Books:*** 4. Non-destructive Testing of Materials and structures by Buyukozturk and Tasdemir: Springer

Mapping of Course Outcomes COs→POs

	Engineering knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment & sustainability	Ethics	Individual & team work	Communication	Project management & finance	Life-long learning
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	2	-	-	-	-	-	-	-
CO3	-	-	-	2	3	-	-	-	-	-	-	-
CO4	-	3	-	-	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE720	**Soil Dynamics**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Soil Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	• CO1: develop a mechanism to design the foundations for resisting vibrations and achieve static equilibrium conditions of structures. • CO2: understand the classical geotechnical failures due to liquefaction and mitigate the same. • CO3: design of foundations in large structures like power plants, other industrial buildings etc., for analysing the vibrating waves which can be isolated and measures for achieving safety of the adjacent foundations.
Topics Covered (Hrs)	Vibration of elementary system, Single degree and two-degree freedom systems, Wave propagation in an elastic, homogeneous, isotropic medium. **(10)** Propagation of waves in saturated media, Behaviour of dynamically loaded soils, Evaluation of dynamic properties of soil. **(10)** Theories for vibration of foundations in elastic media, Design procedures for dynamically loaded foundations for vertical and rocking vibrations. **(14)** Foundations under reciprocating engines, Foundations for forge hammers, motor generators, turbo-generators and crushers. **(10)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Soil Dynamics and Machine Foundation by Swami Saran, GalgotiaPublicaions 2. Vibrations Vibration Analysis and Foundation Dynamics by NSV Kameswara Rao, Wheeler Publishing, New Delhi. 3. Fundamentals of Soil Dynamics by B M Das ***Reference Books:*** 4. Vibrations of Soils and Foundations by Richart Hall and Woods 5. Foundations of Machines-Analysis and Design by Prakash and Puri. 6. Analysis and design of Foundations for Vibrations by P J Moore 7. Dynamics of bases and Foundations by D DBarkar

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	3	2	-	-	-	-	-	1	-	-
CO2	-	3	-	-	-	-	1	-	-	-	-	-
CO3	-	-	3	-	-	-	2	-	-	-	1	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE721	**Environmental Pollution & Control**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
None	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Apply knowledge of different types of environmental affecting the community life pollutants (air, solid wastes and noise) for design solutions. • CO2: Understand basic design philosophies applicable to control and safe disposal of different types of environmental pollutants.

	• CO3: Formulate, analyze, and design basic control and disposal systems of different types of environmental pollutants.
Topics Covered (Hrs)	**Natural & man made sources of pollution**, types of pollutants. **(2)** **Air pollution**: Its effects, measurement, methods of control, air pollution control equipment. **(16)** **Community Solid wastes** – quantity & characteristics, methods of collection, disposal & reuse. **(16)** **Noise pollution** - Its effects, noise measurement, methods of control of environmental noise. **(6)** **Legal aspects** of environmental pollution & control. **(2)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Introduction to Environmental Engineering byM.L. Davis & D.A. Cornwell (Tata McGraw-Hill Education Private Limited, New Delhi) 2. Environmental Engineering by H.S. Peavy, D. R. Rowe & G. Tchobanoglous [McGraw Hill Education (India) Private Limited, New Delhi] ***Reference Books:*** 3. Environmental Engineering – A Design Approach by A.P. Sincero& G.A. Sincero (Prentice – Hall of India Private Limited, New Delhi)

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE722	**Construction Planning and Management**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:			Course Assessment methods				
CEC303 + CES544			Continuous (CT) and end assessment (EA). CT+EA				
Course Outcomes (COs)	• CO1: Learn preliminaries of construction planning and management. • CO2: Learn construction safety aspects. • CO3: Learn contract management. Get exposed to tendering and contracting. • CO4: Learn about the running &operation of government–run–engineering depart., elements of project financing, project selection& use of construction equipment.						
Topics Covered	**Construction planning:** Introduction to planning, Stages of planning, Work breakdown structure, Scheduling, Preparation of schedules for job, materials, labour, equipment and finance, Network techniques in construction management.**(8)** **Organizing construction:** Principles of organization, Types of organization, Site organisation, Temporary services, Job layout. **(6)** **Safety in construction:** Importance of safety& its measures in construction activities.**(3)** **Construction labour:**Welfare facilities, Labour laws. **(3)** **Contract management:** Different types of contracts, Notice inviting tender, Contract documents, Condition of contract, Earnest money, Security money, Termination of contract, Arbitration, Specification – different types. **(8)** **Public works accounts:** Muster roll, Measurement book, Cash book, Material-at-site account, Imprest, Temporary advance, Mode of payment, Bill, Voucher, Running account bill, Final bill, Advance payment to contractor, Secured advance, Stock, Tools and plants. **(7)**						

	Construction practices: Various construction equipment, Factors affecting selection of equipment, Output of various equipment, Time value of money, Investment and operating cost, Depreciation. **(7)**
Text Books, and/or reference material	***Text Books:*** 1. Estimating and costing in civil engineering by B. N. Dutta,theory and practice 2. Estimating, costing and specification in civil engineering by M. Chakraborty 3. Text book of estimating and costing (civil engineering) by G. S. Birdie, Dhanpat Rai & Sons 4. Civil engineering Contracts and Estimates by B. S. Patil, Orient Longman, New Delhi, 1981. 5. PERT & CPM principles and applications by L. S. Srinath, Affiliated East-West Press Pvt. 6. Construction Management and Accounts by V. N. Vazirani, and S. P. Chandola, Khanna Publishers, Delhi-6, 1978. ***Reference Books:*** 7. Management in Construction Industry by P. P. Dharwadker, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, 1992. 8. Building Construction by S. C. Rangawala, Charotar Book Stall, Anand, 1980. 9. Construction equipment and its planning & application by M. Verma, Metropolitan book co. (p) Ltd. New Delhi, 1979

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	-	-	3	-
CO2	-	-	-	-	-	3	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	3	-
CO4	-	-	-	-	-	-	-	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE723	**Open channel Hydraulics**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Fluid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• **CO1:** Understanding mechanics of flow, energy & momentum in an open channel • **CO2:** Computation of different components of flow in an open stream. • **CO3:** Capability for design of different type of open channel for operationalization of water-resources systems						
Topics Covered (Hrs)	**Introduction:** Descriptions, types of flow, state of flow, regime of flow **(2)** **Open-Channels and their properties:** Types, geometry, geometric elements of channel sections, velocity distribution, wide open channel, measurement of velocity, velocity-distribution coefficients and determination, pressure distribution in a channel section, effect of slope on pressure distribution.**(8)** **Energy and Momentum Principles:** Energy, specific energy, criterion for a critical state of flow, interpretation of local phenomena, energy in non-prismatic channels, momentum in open-channel flow, specific force, momentum principle applied to non-prismatic channels. **(6)** **Critical flowcomputations and Applications:** Critical flow, factors, flow computation, hydraulic exponent for flow computation, control&measurement**(6)** **Uniform flow in open channels:**Qualifications, establishment, expressing the velocity of a uniform flow, hydraulic gradient, Equation for uniform flow, Chezy formula, Chezy'sresistance,factor, Manning's formula, Mannining's roughness coefficient, factors, Mannining's roughness coefficient table. **(6)**						

	Computations of Uniform Flow: The conveyance of a channel section, the section factor for uniform-flow computation, the hydraulic exponent for uniform-flow computation, flow in a channel section with composite roughness. Determination of the Normal Depth and Velocity, determination of the Normal and Critical Slopes, problems of uniform flow computation, computation of flood discharge, uniform surface flow **(6)** **Design of Channels for Uniform Flow: (6)** **(a) Non-erodible channels:** Non-erodible channel, non-erodible material and lining, minimum permissible velocity, channel slopes, freeboard, best hydraulic section, determination of section dimensions **(b) Erodible channels with scour not silt:** Method of approach, maximum permissible velocity, method of permissible velocity, tractive force, tractive-force ratio, permissible tractive force, method of tractive force, stable hydraulic section **(c)Grassed channel:** Grassed channel, retardance coefficient, the permissible velocity, selection of grass, procedure of design.
Text Books, and/or reference material(s)	***Text Books:*** 1. Open Channel Hydraulics by K. Subramanya, Fourth Edition, McGraw Hills Education (India) Private Limited, New Delhi. ***Reference Books:*** 2. Open-Channel Hydraulics by V. T. Chow, McGraw-Hill Book Company, Inc., New York

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	3	-	-	-
CO3	-	-	3	-	3	3	-	-	-	3	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE724	**Ground Water**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Fluid Mechanics and Water Resources Engineering		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes (COs) :	• CO1: Understanding of occurrence, distribution, storage and transmission of water below the ground level. • CO2: Understanding of mechanics of flow of water under the ground • CO3: Techniques for exploitation of ground water on sustainable basis. • CO4: Ability to develop models for storage and transmission of ground water. • CO5: Development of capabilities in recharging, management & conjunctive use of ground water
Topics Covered (Hrs)	**Fundamentals of ground water:** Introduction – Characteristic of Ground water – Distribution of water - ground water column –Permeability - Darcy's Law - Types of aquifers - Hydrogeological Cycle – water level fluctuations. **(6)** **Hydraulics of flow:**Storage coefficient - Specific field - Heterogeneity and Anisotropy - Transmissivity– Governingequations of ground water flow - Steady state flow – DupuitForchheimer assumptions – Velocity potential - Flow nets**(6)** **Estimation of parameters:**Transmissivity and Storativity – Pumping test - Unsteady state flow - Thiess method – Jacobmethod - Image well theory – Effect of partial penetrations of wells - Collectors wells. **(6)** **Ground water development:** Infiltration gallery - Conjunctive use - Artificial recharge

	Rainwater harvesting - Safe yield –Yield test – Geophysical methods – Selection of pumps. **(6)** **Water quality:** Ground water chemistry - Origin, movement and quality - Water quality standards – Saltwater intrusion –Environmental concern**(6)** **Artificial recharge:** Artificial recharge of ground water; concept of artificial recharge – recharge methods, relative merits, Application of GIS and Remote Sensing in Artificial Recharge of Ground Water **(3)** **Groundwater management:** Ground water basin management; concepts of conjunction use**(3)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Ground Water Hydrology by H.M. Raghunath, Wiley Eastern Ltd., 2000. 2. Ground Water Hydrology by D. K. Todd, John Wiley and Sons, 2000. 3. Ground Water by Bawvwr, John Wiley & Sons 4. Groundwater System Planning & Management by R. Willes & W.W.G. Yeh, Printice Hall. 5. Applied Hydrogeology by C.W. Fetta, CBS Publishers & Distributers. ***Reference Books:*** 6. Principles of Pavement Engineering by Nick Tom

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-
CO3	-	3	3	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	3	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	3	3	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE725	**Hydrology and Irrigation Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)			Course Assessment methods				
Physics and Fluid Mechanics			Continuous (CT) and end assessment (EA). CT+EA				
Course Outcomes (COs) :	• CO1: Understanding of occurrence, distribution, storage & transmission of water in different form in space, over& below surface of earth, data collection & processing • CO2: Understanding flow generation, occurrence of flood, drought, environmental flow requirement. • CO3: Realizing need for food sufficiency, crop water, irrigation requirement, method & design of infrastructures for irrigation requirement.						
Topics	**Introduction**: Brief introduction to Hydrology and Irrigation system **(7)** **Diversion head-works**: Definition of weirs and barrages and their classification, Layout of typical diversion head-works and function of its components. **(3)** **Concrete gravity dams:** Forces acting, Elementary profile, Design of gravity dams **(3)** **Earthen dams:** Types, Causes of failure, Seepage control, Slope protection **(3)** **Hydraulic power:** Thermal-water power, systems, arrangement, equipment, operation **(2)** **River navigation:**Requirements of navigable waterways, Methods of achieving navigability, Open channel methods, Navigation dams, Navigation locks, Financing river navigation projects.**(4)** **Ground water:** Occurrence, Well hydraulics, Regional aquifer hydraulics, Ground water						

Covered (Hrs)	quality. **(4)** **Flood damage mitigation:**Design flood, Flood mitigation, Improvement, Evacuation and flood proofing, Land management and flood mitigation, Flood forecasting, Flood plain management, Economics of flood mitigation **(6)** **Planning for water resources development:** Level, Phases, objectives, formulation, evaluation, Environmental issues, Systems analysis, multiply purpose projects. **(2)** **Engineering economy in water resources planning:** Social importance, Annual cost comparisons, Interest and taxes, Frequency and economy, Economy studies for public works, Cost allocation. **(4)** **Planning for water resources development:** Level of planning, Phases, Objectives, Data requirements, Project formulation and evaluation, Environmental considerations, Systems analysis, Multiple purpose projects. **(4)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Engineering Hydrology by K. Subramanya, Fourth Edition, McGraw Hills Education (India) Private Limited, New Delhi 2. Irrigation and Water Power Engineering by B. C. Punmia, B. B. Pande, A. K. Jain & A. Kumar, 16th Edition, Laxmi Publications (P) Limited, new Delhi. ***Reference Books:*** 3. Hydrology by V. T. Chow, McGraw-Hill Book Company, Inc., New York

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	3	3	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	3	3	3	3	3	3	3

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE730	**Principles of Reliability**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)			Course Assessment methods				
Engineering Mathematics and Design of Concrete Structures			Continuous (CT) and end assessment (EA). CT+EA				
Course Outcomes (COs) :	• CO1: Understand of reliability theory based on knowledge of fundamentals of probability and statistics. • CO2: Apply Monte carlo simulation technique to solve different civil engineering problems. • CO3: Understand the different reliability analysis methods. • CO4: To design the elements of civil engineering structures by using reliability methods.						
Topics Covered (Hrs)	**Basic statistics and probability:** Definition of probability, Axioms of probability, Conditional probability, Total probability theorem, Bayes' theorem, Basics of statistics, Definition of random variable, Different functions of random variable, Discrete and continuous random variables, Multiple random variables, probability distribution of random variables (Bernoulli and Binomial distribution, Poisson, geometric, hypergeometric, uniform, normal, lognormal, gamma). **(10)** **Simulation technique:** Monte Carlo method, theory and applications. **(5)** **Reliability analysis:** Definition of reliability, Limit state function, Reliability Index, Different classical reliability analysis methods, First order reliability method, Hasofer-Lind reliability						

	method, Rackwitz-Fiessler reliability method, Introduction to second order reliability method. **(15)** **Reliability-based design:** Load and resistance parameter model, reliability based code format, Calibration of partial safety factors for a level I code, Applications to solve design problems. **(10)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Structural Reliability Analysis and Design by Ranganathan, Jaico Publishing House 2. Probability, Reliability and Statistical Methods in Engineering Design by A. Halder and S. Mahadevan, John Wiley and Sons. New York. ***Reference Books:*** 3. Probability Concepts in Engineering and Design by Ang and Tang, John Wiley. 4. Structural Reliability Analysis and Prediction by R. E. Melchers and A. T. Beck, John Wiley.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	1	1	-	3	-	-	-	-	-	-	-	-
CO3	3	-	-	-	-	-	-	-	-	-	-	-
CO4	1	-	3	-	-	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE731	**Offshore Structural Dynamics**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)			Course Assessment methods				
Solid mechanics & Structural analysis		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Identify the types of offshore structures, parameters governing solid-fluid interaction and environmental forces acting on offshore structures. • CO2: Apply static methods of analysis for stresses in Offshore structures • CO3: Solve for response analysis of offshore structures – single and multi-degree of freedom problems, frequency and time domain analyses. • CO4: Evaluate responses under random wanes						
Topics Covered (Hrs)	**Introduction:** Loads and structural terms of different types of offshore structures.**(2)** **Fundamental of offshore structural analysis:** Stress and strain, bending of beams, Beams under torsion, Beam deflection, Bucklingof beams, Bernoulli-Euler beam theory, Matrix analysis of plane, Space trusses,Plane space frames.**(8)** **Environmental loadings:** Winds forces, Ocean surface waves, Wave loads on offshore structures, Buoyantforces, Current loadings, additional environmental loadings.**(6)** **Static methods of analysis:**Frame analysis of steel offshore structures, bending stresses correction from axial loading, Pressure induced stresses in steel structures, Ring stiffeners, Analysis of joints.**(10)** **Dynamics of offshore structures:**Modelling of offshore structures-.Single and multi-degree freedom systems- Dynamic amplification factor- Response of offshore structures- Coupled and uncoupled motions- Frequency domain analysis- Time domain analysis- New Mark-Beta method- Wilson θ method- Response analysis of fixed platforms- Response analysis of compliant platforms. Response in Random Waves**(16)**						

Text Books, and/or reference material(s)	***Text Books:*** 1. Offshore Structural Engineering by Thomas H Dawson, Prentice Hall, 1983 2. Dynamic Analysis and Design of Ocean Structures by Srinivasan Chandrasekaran, Springer, 2015. 3. Dynamics of Offshore Structures by Wilson, J. F., John Wiley, 2002. ***Reference Books:*** 4. Offshore Mechanics by MadjidKarimirad, Constantine Michailides and Ali Nematbakhsh, Wiley, 1 edition 5. Offshore structures – Vol. 1 & 2 by Clauss, G, Lehmann, E &Ostergaard, C., Springer-Verlag, 1992.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	1	-	-	-	-	-
CO2	3	-	2	-	3	-	-	-	-	-	-	-
CO3	3	-	2	-	3	-	-	-	-	1	-	-
CO4	3	-	2	-	3	-	-	-	-	1	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE732	**Pre-stressed Concrete**	**PCL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Solid mechanics and Design of Concrete Structures		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs)	• CO1: Apply knowledge of solid mechanics & concrete structures for design solutions. • CO2: Understand basic design philosophies applicable to pre-stressed concrete structures. • CO3: Formulate, analyse, and design basic components of Civil Engineering Pre-stressed Concrete structures.						
Topics Covered (Hrs)	**Introduction:** Basic principles, advantage, Comparison with RC, Types of pre-stressing and Stress analysis **(4)** **Materials:** Specifications and characteristics of concrete and high tensile steel **(2)** **Loss of Prestressed**: Different type of loss with derivation and numerical problems **(4)** **Flexural Analysis:** Derivation of moment of resistance, Pre-stressing force and eccentricity with numerical problems **(6)** **Shear and torsion:** Design of beam for shear and torsion **(5)** **Deflection and Cracking:** Cause and requirement along with numerical problems**(5)** **Design of end blocks:** Transmission length, design of bearing plate and burst reinforcement **(4)** **Member Design:** One way slab and beam design, two-way pre-stressing, Circular pre-stressing, Partial pre-stressing, Composite construction with pre-stressed concrete and reinforced concrete. **(10)**						

Text Books, and/or reference material(s)	***Text Books:*** 1. Prestressed Concrete, 5th Edition by N. Krishna Raju, Tata McGraw-Hill Publishing Company Limited, New Delhi. 2. Prestressed Concrete, 5th Edition, by S.Ramamrutham, DhanpatRai Publishing Co. Pvt. Ltd. New Delhi. 3. IS 1343: 2012, Prestressed Concrete – Code of Practice (2nd Revision), BIS, New Delhi. 4. www.nptel.ac.in ***Reference Books:*** 5. Fundamentals of PrestressedConcreteby N. C. Sinha& S. K. Roy, S.Chand& Company Ltd, New Delhi

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE733	**Advanced Concrete Technology**	**PCL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Solid mechanics and Concrete Technology	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs)	• CO1: Acquire knowledge of selection and application of concrete making materials • CO2: Understand the properties of concrete at different stages • CO3: Gain an integrative ideaon different concretes
Topics Covered (Hrs)	**Introduction:**Brief discussion on concrete making materials, fresh and harden concrete and mix design **(10)** **Elasticity, Creep & Shrinkage:** Definitions and meaning, factors affecting, measurement and types. **(6)** **Durability of Concrete:** Volume change, Permeability, Mass concrete, Freezing & thawing, Sulphate & Acid attack, Alkali-Aggregate reactions, Crack, Cover to Reinforcement **(6)** **Testing of Harden Concrete:** Compression, Flexural, Ring Tension, Core and non-destructive test **(6)** **Special Concrete:** Mass,LightWeight,High Density, Fibre Reinforced, Cold Weather, Hot Weather, Prepacked, Vacuum, Shotcrete, Ferro cement, Self-Compacted, Reinforced, Pre-stressed & etc. Concrete **(14)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Engineering Materials byS. C. Rangwala, K. S. Rangwala and P. S. Rangwala, Charotar Publishing House, Anand 2. Concrete Technology byM.S. Shetty, S. Chand Publisher, New Delhi 3. IS 10262: 2009, Concrete Mix Proportioning-Guidelines (1st Revision), BIS, New Delhi. 4. IS 383: 1970, Specification for Coarse and Fine aggregates from natural sources for concrete (2nd Revision) BIS, New Delhi. ***Reference Books:*** 1. Concrete Technology by M. L. Gambhir, Tata McGraw Hill and www.nptel.ac.in

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	3	-	-	-	-	-	-	-	-	1
CO2	2	-	3	-	-	1	1	-	-	-	-	1
CO3	2	-	3	-	3	1	1	2	-	-	-	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE734	**Advanced Structural Mechanics**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: To develop basic understanding of the fundamental concepts of the advanced topics. • CO2: To define the stress and strain tensors for structural members and to write the stress-strain relationships. • CO3: To evaluate the state of stress or state of strain with respect to the different theories of failure and compare. • CO4: To apply the principles of structural mechanics to special structures.
Topics Covered (Hrs)	**Analysis of stress:** Definition of stresses; stress matrix; state of stress; Cauchy's stress relations; stress transformation, principal stresses; equations of equilibrium; different types of stresses; polar coordinates; three-dimensional Mohr's circle. **(7)** **Analysis of strain:** Definition of strains; deformation vector; strain-displacement relations; strain matrix; principal strains; total distortion and rigid body rotation; strain compatibility conditions; volumetric strain; polar coordinates. **(6)** **Stress-strain constitutive relations:** (4) **Theories of failure:**(3) **Analysis of non-prismatic members**: General Euler-Bernoulli Law; linear Euler-Bernoulli equation; effect of bending of non-prismatic members. **(2)** **Thin Walled Pressure Vessels**: Stresses, strains in cylindrical and spherical vessels; change in volume, strengthening of thin cylinders, solution of numerical problems to implement the above concepts. **(4)** **Thick Walled Pressure Vessels:** Cylinders and Spheres: stresses; compatibility; Lame's equation; special case of solid shaft; thick spherical shells. **(4)** **Curved Beams**: Introduction; stresses in curved beams; eccentricity; rings under loads; distribution of stresses and bending moments in rings. **(4)** **Unsymmetrical Beam Bending**:Introduction; beams with doubly symmetric cross-sections; beams with arbitrary cross sections. **(4)** **Introduction To Plates** (4)
Text Books, and/or reference material(s)	***Text Books:*** 1. Solid Mechanics by S.M.A. Kazimi, Tata McGraw-Hill Publishing Company Limited 2. Advanced Mechanics of Solids by L.S. Srinath, Tata McGraw-Hill Publishing ***Reference Books:*** 3. Mechanics of Solids by Abdul Mubeen

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	3	2	-	-	-	-	-	-	-	-
CO3	3	-	3	2	2	-	-	-	-	-	-	-
CO4	-	-	-	2	-	-	-	-	-	-	-	-

EIGHTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE810	**Sediment Transport**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
CEC 302, CEC 601.		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs):	• CO1: Understanding of the origin and mechanism of sediment transport • CO2: Development of capabilities to analyze sediment load. • CO3: Ability to develop model to predict sediment load. • CO4: Capability to design stable channel to carry the predicted sediment load						
Topics Covered (Hrs)	**Introduction:(2)** **Sediment properties:** particle size shape and density, fall velocity, viscosity, colloids and flocculation. Introduction **(4)** **Threshold of particle motion. (4)** **Sand transport by air:** Surface creep, effects of sand movement on wind, instability of a flat sand surface, ridges and dunes. **(4)** **Sediment movement in water:** bed features and meanders, analytical models, stresses in flow of fluid-solid mixtures. **(4)** **Channel roughness and resistance to flow.(2)** **Sediment load:** Bed Load, Bed Forms; Effective bed roughness; Armouring, suspended sediment, diffusion approach, energy approach, statistical approach, suspended sediment load, total Load. **(8)** **Stable Channel Design**: The empirical stable channel design - Tractive force method of stable channel design - Drag distribution and resistance to motion - Design values for boundary shear - The stable cross-section - Design by tractive force method **(8)** **Cohesive sediments: (2)** Erosion, deposition, scour, local scour at different structures. **(2)** Dimensional Analysis and Similitude **(2)**						
Text Books, and/or reference material(s)	***Text Books:*** 1. Mechanics of Sediment Transportation and Alluvial Stream Problems by R. J. Garde, K. G. Ranga Raju, Revised Third Edition, New Age International Publishers, and New Delhi. 2. Loose boundary hydraulics by A. J. Raudkivi, 2nd edition Pergamon press ***Reference Books:*** 3. Sediment Transport by V. T. Chow, McGraw-Hill Book Company, Inc., New York						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	3	-	-	-
CO2	-	3	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	3	-	-	3	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	3	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE811	**Slope Stability and Reinforced Earth**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Foundation Engineering		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: learn basic mechanism of reinforced earth. • CO2: design wall with reinforced backfill • CO3: analyze stability of reinforced slopes						
Topics Covered (Hrs)	**Introduction,** Basic mechanism of reinforced earth, Practical application. **(6)** **Basic components of reinforced soil**: Soil or fill matrix, Reinforcements, facing elements. **(6)** **Strength characteristics of reinforced soil**: Basic concept, Sigma and Tau models, laboratory studies, sliding shear test, pull-out tests. **(8)** **Wall with reinforced backfill**: Pressure intensity on the wall, Stability against sliding, overturning and bearing failure, Increase of earth pressure due to a line load on the backfill, design procedure. **(10)** **Methods of Slope Stability**: Taylor Charts, Method of Slices, Effect of Tension Cracks, Vertical Cuts. Bishop's Analysis. Non-circular Failure Surfaces, Stabilization of slopes: Drainage measures, Soil reinforcement (geosynthetics/soil nailing etc). **(15)**						
Text Books, and/or reference material(s)	***Text Books:*** 1. Reinforced Earth & Geotextiles by Koerner 2. Reinforced Earth & Geotextiles by G. V. Rao 3. Earth and Earth-Rock Dams by Sherard, Woodward, Gizienski and Clevenger. John Wiley &. Sons. 1963 4. Earth and RockFill Dams by Bharat Singh and H. D. Sharma, 1999 ***Reference Books****:* 5. Slope Stability and Stabilisation methods by L. W. Abramson, T. S. Lee, and S. Sharma, John Wiley & sons. (2002) 6. The Stability of Slopes by E. N. Bromhead, (1992), Blackie academic and professional, London. 7. Earth &Rockfill Dams, Principles of Design and Construction by Christian, Kutzner Published Oxford and IBH. 8. Handbook of Slope Stabilization by J. A. R. Ortiago, and A. S. F. J. Sayao, 2004.						

Mapping of Course Outcomes COs→POs

	Engineering knowledge	Problem analysis	Design/development of solutions	investigations of complex	Modern tool usage	The engineer and society	Environment & sustainability	Ethics	Individual & team work	Communication	Project management & finance	Life-long learning
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	2	3	-	-	-	-	-	-	-	-	-
CO3	-	3	-	2	-	-	-	-	-	-	-	-

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEE812</td><td>Soil Structure Interaction</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisite(s)</td><td colspan="5">Course Assessment methods</td></tr>
<tr><td colspan="3">Structural Analysis, Soil Mechanics and Foundation Engineering</td><td colspan="5">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">• CO1: Understand the basis of soil-structure interaction.
• CO2: Understand various soil interaction models like beams on elastic foundation (Winkler beam model), infinite beam, finite beam models.
• CO3: Apply soil-structure interaction models to different type of foundations like pile, sheet pile walls (cantilever and anchored sheet pile walls).
• CO4: Analyse the foundation of different civil structures with considering soil-structure interaction in static as well as dynamic conditions.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Introduction, Superstructure-foundation interaction, Analytical formulations. (4)
Interaction problems of shallow foundation combined footing, Rigid method, and Flexible method. (5)
Beams on elastic foundation, Infinite beam, Finite beam, Modulus of subgrade reaction and effecting parameters. (8)
Sheet pile wall, Cantilever and anchored sheet pile wall, Fixed earth support, Free earth support. (6)
Retaining walls, Conduits, Load on different types of conduits, Design charts. (5)
Braced excavation, Pressure distribution in braced walls, Estimation of strut load etc., Stability of bottom of excavation.(4)
Piles under different loading conditions, Analysis under lateral load, Different approaches, Mechanism of failure, Ultimate load, Deflections, Elastic continuum approach, Analysis and design. (8)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Geotechnical Engineering: Principal and Practices of Soil Mechanics and foundation Engineering by V N.S. Murthy,
2. Foundation analysis and Design by J. E. Bowles.
3. Basic and Applied Soil Mechanics by G.Ranjan and A.S.Rao
Reference Books:
4. Advanced Geotechnical Engineering soil-structure Interaction using Computer and Material Models by C. S. Desai, and M. Zaman
5. Advanced Soil Mechanics by B. M. Das, McGraw Hills Publishers</td></tr>
</table>

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-
CO3	2	-	2	-	-	-	-	-	-	-	-	-
CO4	1	2	-	1	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE813	**Industrial Wastes**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Environmental Engineering		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Apply knowledge of different types of industrial pollutants (air, solid waste and wastewater) for design solutions. • CO2: Understand basic design philosophies applicable for control and safe disposal of different types of industrial pollutants. • CO3: Formulate, analyze, and design basic control and disposal systems of different types of industrial pollutants.						
Topics Covered (Hrs)	**Industrial sources of pollution**, types of pollutants. **(5)** **Air pollution** – Its effects, measurement, methods & equipment of control**. (15)** **Solid wastes** – quantity & characteristics, methods of collection, disposal & reuse**. (12)** **Wastewater** – characteristics, methods of collection, treatment & disposal. **(10)**						
Text Books, and/or reference material (s)	***Text Books:*** 1. Environmental Engineering byH.S. Peavy, D. R. Rowe & G. Tchobanoglous, McGraw Hill Education (India) Private Limited, New Delhi 2. Introduction to Environmental Engineering byM.L. Davis & D.A. Cornwell, Tata McGraw-Hill Education Private Limited, New Delhi ***Reference Books:*** 3. Environmental Engineering – A Design Approach by A.P. Sincero& G.A. Sincero, Prentice – Hall of India Private Limited, New Delhi 4. Industrial Water Pollution Control byW.W. Eckenfelder, Jr. (McGraw-Hill Higher Education)						

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE814	**Water resource System Planning and Management**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Fluid Mechanics, Irrigation Engineering, Water Resources Engineering, Economics and Computer Applications		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	• CO1: Understanding of different aspects of systems of water resources • CO2: Learning of optimization techniques, linear and dynamic Programming. • CO3: Ability to formulate modelsof reservoir systems,size, operation and hydropower production						
	Introduction: Overview and Role of engineers **(2)** **Engineering economic analysis:** Principles of engineering economics, Mathematics of economic analysis, Price theory and resources allocation, Conditions of project optimality, Benefit-cost analysis, Discount rate. **(5)**						

Topics Covered (Hrs)	**Identification and evaluation of water management plans:** System concept, System design methodology, Optimal design, Introduction to classical optimisation techniques with simple numerical examples, Simulation analysis. **(5)** **Planning for flood control:** Planning context, Developing the supply, Estimating the demand, Project feasibility. **(5)** **Planning for drainage:** Planning context, Developing the supply, Estimating the demand, Project feasibility. **(5)** **Planning for water supply:** Planning context, Developing the supply, Estimating irrigation demand, Estimating urban demand and Project feasibility. **(5)** **Planning for hydroelectric power:** Planning context, Developing the supply, Estimating the demand, Project feasibility**. (5)** **Planning for navigation:** Planning context, Developing the supply, Estimating the demand, Project feasibility**. (5)** **Irrigation planning and operation:** Planning context, Developing the supply, Estimating the demand, Project feasibility**. (5)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Water Resources Systems – Modelling Techniques and Analysis by S. Vedula and P. P. Mujumdar, Tata McGraw-Hill Publishing Company Limited, New Delhi. ***Reference Books:*** 2. Irrigation System Design – An Engineering Approach by H. Cuenca, Richard, Prentie Hall, Englewood Cliffs, New Jersey 07632 3. Water Demand Management by Butler, David and Memon, Fayyaz Ali, IWA Publishing, London

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	3	-	-	-	-	-	-	-	-	-
CO3	-	-	3	-	-	-	-	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEE815	**MachineFoundation**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)			Course Assessment methods				
Mechanics of structures			Continuous (CT) and end assessment (EA). CT+EA				
Course Outcomes (COs) :	• CO1: Acquire knowledge of Machines and its Foundation: Types and Forces acting upon, dynamic analysis • CO2: Ability to conduct Field-Experiment and Analyze the data with interpretation for determining dynamic properties of Soil • CO3: Ability to Design Suitable Foundations based on Soil as a Spring, and as a Half-Space continuum • CO4: Ability for understanding the need of future studies						
Topics Covered	**Single Degree freedom system:**Free vibration of Single Degree freedom system, natural frequency and time period, damping, Amplitude, Forced vibration, dynamic magnification factor **(5)** **Two Degree Freedom System:**Free and Forced Vibration of Two Degree Freedom System, Natural frequencies and their arrangement, Eigen value and Eigen vector, normal coordinates,						

(Hrs)	Effect of damping, generalized mass and stiffness matrices. **(7)** **Soil Stiffness and damping:**Experimental Procedure for finding out Soil Stiffness and damping. **(2)** **Machine Vibration:**Type of Machines, permissible amplitude vs. time period, Soil modeling as linear un-damped springs. Soil as Half-Space, inclusion of damping, embedment effect. **(6)** **Foundation design:**Foundation analysis and design as linear spring, vertical vibration, pure sliding and rocking vibration. **(6)** **Couple vibration of sliding and rocking. (6)** **Elastic half-space approach of analysis and design(8)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Hand book of Machine Foundations by P. Srinivasulu and C.V. Vaidyanathan, Tata-Mc-Graw-Hill Publishing Company ltd. ***Reference Books:*** 2. Design Aids in Soil Mechanics and Foundation Engineering by S.R. Kaniraj, Tata-Mc-Graw-Hill Publishing Company ltd.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	3	-	-	-	-	-	-	-
CO2	-	3	-	-	2	-	-	-	-	-	-	-
CO3	-	-	3	-	-	2	-	1	-	-	-	-
CO4	-	-	-	-	-	2	-	1	-	-	-	3

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN CHEMICAL ENGINEERING

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in _____ Senate # ______________ # Item no: ______

DEPARTMENT OF CHEMICAL ENGINEERING

Program Name: Bachelor of Technology in Chemical Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR CHEMICAL ENGINEERING - B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics – I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CHC301	Process Calculations	3	1	0	4.0	4
3	CHC302	Chemical Engineering Thermodynamics	3	1	0	4.0	4
4	CHC303	Fluid Mechanics	3	1	0	4.0	4
5	CYC331	Chemistry - II	3	0	0	3.0	3
6	CYS381	Chemistry Laboratory - II	0	0	3	1.5	3
7	CHS351	Chemical Engineering Computing Laboratory - I	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CHC401	Heat Transfer	3	1	0	4.0	4
2	CHC402	Mechanical Operation	3	1	0	4.0	4
3	CHC403	Mass Transfer- I	3	1	0	4.0	4
4	MEC432	Mechanical Design of Equipment and Components	3	0	0	3.0	3
5	YYO44*	Open Elective - I	3	0	0	3.0	3
6	CHS451	Fluid Mechanics Laboratory	0	0	3	1.5	3
7	CHS452	Process Equipment Design - I Sessional	0	0	3	1.5	3
8	WSS481	Workshop Practice- II	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CHC501	Chemical Reaction Engineering	3	1	0	4.0	4
2	CHC502	Mass Transfer- II	3	1	0	4.0	4
3	CHC503	Chemical Process Technology	3	1	0	4.0	4
4	CHC504	Process Control and Instrumentation	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	CHS551	Heat Transfer Laboratory	0	0	3	1.5	3
7	CHS552	Mechanical Operations Laboratory	0	0	3	1.5	3
8	CHS553	Process Equipment Design - II Sessional	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	15	4	9	23.5	28

Semester - VI							
Sl.	Code	Subject	L	T	S	C	H
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	CHC601	Transport Phenomena	3	1	0	4.0	4
3	CHC602	Petroleum Refining and Petrochemicals	3	1	0	4.0	4
4	CHC603	Process Modelling and Simulation	3	0	0	3.0	3
5	CHE610 --	Depth Elective - 1	3	0	0	3.0	3
6	CHS651	Fuel Laboratory	0	0	3	1.5	3
7	CHS652	Reaction Engineering Laboratory	0	0	3	1.5	3
8	CHS653	Mass Transfer Laboratory	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	2	9	21.5	26
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	CHE710 --	Depth Elective - 2	3	0	0	3.0	3
3	CHE710 --	Depth Elective - 3	3	0	0	3.0	3
4	CHE710 --	Depth Elective - 4	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	CHS751	Process Control and Instrumentation Laboratory	0	0	3	1.5	3
7	CHS752	Chemical Engineering Computing Laboratory- II	0	0	3	1.5	3
8	CHS753	Computer Aided Process Equipment Design Laboratory	0	0	3	1.5	3
9	CHS754	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
10	CHS755	Project - I	0	0	3	1.0	3
		TOTAL	15	0	14	21.5	29
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CHE810 --	Depth Elective - 5	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	CHS851	Project - II	0	0	15	5.0	15
5	CHS852	Project Seminar	0	0	0	1.0	0
6	CHS853	Viva Voce	0	0	0	1.0	0
		TOTAL	9	0	15	16.0	24

CURRICULUM AND SYLLABUS FOR B.TECH. IN CHEMICAL ENGINEERING

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45.0	22.0	22.5	23.5	21.5	21.5	16.0	172.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CHE610	Chemical Reactor Analysis
CHE611	Industrial Pollution Control and Treatment
CHE612	Non-conventional Energy Engineering
CHE613	Combustion Engineering
CHE614	Artificial Intelligence in Chemical Industries

7th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CHE710	Energy Sources & Utilization
CHE711	Bioprocess and Bioreactor Engineering
CHE712	Process Engineering
CHE713	Chemical Plant Design and Economics
CHE714	Process Safety in Chemical Industries
CHE715	Membrane Separation Processes
CHE716	Process Intensification
CHE717	Colloids and Interface Engineering
CHE718	Pinch Technology
CHE719	Energy Management and Process Optimization in Chemical Industry
CHE720	Self-Mastery

8th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CHE810	Multiphase Flow
CHE811	Process Analysis and Optimisation
CHE812	Boiling Heat Transfer
CHE813	CFD Applications in Chemical Engineering
CHE814	Nanotechnology

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of function, limit, differentiation, and integration.	CT+MT+EA

Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence

Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHC01</td><td>Engineering Physics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites:</td><td colspan="5">Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems.
CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field.
CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization.
CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Harmonic Oscillations - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8]
Wave Motion - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3]
Introductory Quantum Mechanics - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8]
Interference & Diffraction - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13]
Polarisation - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5]
Laser and Optical Fiber - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons
2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications
3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill.</td></tr>
</table>

	REFERENCE BOOKS: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions,						

<table>
<tr><td></td><td>octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)
v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3)
INORGANIC CHEMISTRY
i. Coordination Chemistry: Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5)
ii. Bioinorganic Chemistry: Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3)
iii. Inorganic Materials: Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2)
iv. Organometallic Chemistry: π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4)
PHYSICAL CHEMISTRY
i. Thermodynamics: 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4)
ii. Chemical Kinetics: 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4)
iii. Electrochemistry: Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2)
iv. Absorption: Physical and Chemical absorption, Absorption isotherms. (1)
v. Catalysis: Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td><u>Suggested Text Books:</u>
(i) Physical Chemistry by P. Atkins, Oxford
(ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu.
(iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall
<u>Suggested Reference Books:</u>
Organic Chemistry:
(i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press
(ii) Engineering Chemistry: Wiley
(iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan
Inorganic Chemistry:
(i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education
(ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein.
(iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford
Physical Chemistry:
(i) Physical Chemistry by G.W Castellan
(ii) Physical Chemistry by P. C. Rakshit</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	
	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]

Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.						
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]						

Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6]						

	Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)
Text Books, and/or reference	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP)

material	2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	**WORKSHOP PRACTICE**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes

- CO1: Study and practice on machine tools and their operations
- CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
- CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
- CO4: Develop basic electrical engineering knowledge for house wiring practice

Topics Covered

M/c shop & Carpentry shop -- 3X3= 9hrs.

- Introduction on machining process.
- Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
- Introduction to woods- Types, structure, disease and defect of wood.
- Introduction to wood working machines and tools.
- Making of dovetail joint and bridle joint.

Welding Shop & Sheet metal -- 3X3= 9hrs.

- Introduction to welding.Safety and precautions in welding.
- Formation of weld bead by SMAW on mild steel flat.
- Formation of weld bead by oxy-fuel welding on mild steel flat.
- Introduction to sheet Metal works.
- Tools and Machines used in sheet metal works.
- Concept of development, marking out of metal sheets.
- Cutting and joining of metal sheets.
- Safety precautions, General warning needed in the shop floor.

Black smithy & Foundry -- 3X3= 9hrs.

- Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
- Safety and precautions in blacksmithy.
- Making of bars of different cross-sections.

	• Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology. • Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service.

	• Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the

halt.

- FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing.
- FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out.
- FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt.
- FD-7 Turning on the March and Wheeling.
- FD-12 Parade practice.

TAEKWONDO

- Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc.
- Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc.
- Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc.
- Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc.

NSS

- Swachha Bharat Mission
- Free Medical Camp
- Sanitation drive in and around the campus.
- Unnat Bharat Abhiyaan
- MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC 02</td><td>MATHEMATICS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic concepts of set theory, differential equations, and probability.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
• CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
• CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
• CO4: To grasp the basic concepts of probability theory.</td></tr>
</table>

Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
	Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10thed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2" colspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CSC01</td><td>INTRODUCTION TO COMPUTING</td><td colspan="2">PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of computer.</td><td colspan="7">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates.
CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators.
CO3: Develop conditional and iterative statements to write C programs.
CO4: Exercise user defined functions to solve real time problems
CO5: Inscribe C programs that use Pointers to access arrays, strings and functions.
CO6: Exercise user defined data types including structures and unions to solve problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2]
Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1]
Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2]
Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1]
C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2]
Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8]
Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5]
Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5]
Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10]
Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium 1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons						

	1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback

	7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) /Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.
• CO4: introduce the basic concept of single-phase transformer.
• CO5: analyze the transient phenomena in electrical circuits with DC</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Overview of Electrical power generation systems (2)
Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4)
Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4)
Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8)
Transients with D.C. excitation for R-L and R-C circuits. (3)
Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10)
Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6)
Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)</td></tr>
</table>

Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC01</td><td>LIFE SCIENCE</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism.
CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa
CO3: To introduce molecular biology to understand biological processes in various applications.
CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens.
CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Cell Biology (4)
a) Introduction to life science: prokaryotes & eukaryotes
Definition; Difference
b) Introduction to cells - Define cell, different types of cell
c) Cellular organelles - All organelles and functions in brief
d) Cellular communications
Introduction to basic signaling; endocrine, paracrine signaling; concepts of</td></tr>
</table>

	receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions

	e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2						

	Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output signals.
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td>ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: understand the principle of superposition.
• CO2: understand the principle of maximum power transfer
• CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp.
• CO4: understand the calibration of energy meter.
• CO5: understand open circuit and short circuit test of single-phase transformer.
• CO6: analyze RLC series and parallel circuits
• CO7: understand three phase connections.
• C08: understand determination of B-H curve</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
1. To verify Superposition and Thevenin’s Theorem.
2. To verify Norton and Maximum power transfer theorem
3. Characteristics of fluorescent and compact fluorescent lamp
4. Calibration on energy meter
5. To perform the open circuit and short circuit test on single phase transformer
6. To study the balanced three phase system for star and delta connected load
7. Characteristics of different types of Incandescent lamps
8. Study of Series and parallel R-L-C circuit
9. Determination of B-H Curve for magnetic material</td></tr>
<tr><td>Textbooks, and/or reference material</td><td colspan="7">Textbooks:
1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma, H U Ezea
2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Pub)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3

CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)#**	**Total Hours**	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli.						

	ATHLETICS • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON**

	• Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service. • Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CO-PO Mapping and Matrix

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	3	3	1	2	-	-	-	-	1	-	-	-
	CO2	3	3	1	2	-	-	-	-	1	-	-	-
	CO3	3	3	1	2	-	-	-	-	1	-	1	1
	CO4	3	-	-	2	-	2	-	-	1	-	-	-
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1
CYC01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1

	CO5	3	2	1	-	1	1	1	-	2	1	-	1
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-
MAC02	CO1	2	3	1	3	-	-	-	-	2	-	-	-
	CO2	2	3	1	2	-	-	-	-	2	-	-	-
	CO3	2	2	2	3	2	-	-	-	3	-	1	1
	CO4	2	3	2	3	2	1	1	-	2	-	-	-
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-
ECC01	CO1	-	-	-	-	-	-	-	-	-	-	-	-
	CO2	-	-	-	-	-	-	-	-	-	-	-	-
	CO3												
	CO4	-	-	-	-	-	-	-	-	-	-	-	-
EEC01	CO1	3	1	-	-	2	-	-	-	-	1	-	-
	CO2	2	3	2	-	2	-	-	-	-	-	-	-
	CO3	2	3	1	-	-	-	-	-	-	1	-	-
	CO4	3	1	2	-	1	-	-	-	-	-	-	-
	CO5	3	1	2	-	1	-	-	-	-	-	-	-
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

EES51	CO1	3	-	2	-	3	-	-	-	1	-	-	-
	CO2	3	-	2	-	3	-	-	-	1	-	-	-
	CO3	2	3	2	2	1	-	2	-	1	-	-	-
	CO4	2	3	1	2	2	-	1	-	1	1	-	-
	CO5	2	3	1	2	2	-	-	-	1	-	-	-
	CO6	2	3	2	2	2	-	-	-	1	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

THIRD SEMESTER

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td>MATHEMATICS-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Basic knowledge of topics included in MAC01 & MAC02</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
• CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
• CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
• CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module - I
Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE;</td></tr>
</table>

	Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14 hrs] **Module - II** **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations.[14 hrs] **Module - III** **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17 hrs.] **Module - VI** **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [11 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar& R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig Suggested Reference Books: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC331	CO1	3	3	3	2	2	1	2	-	-	-	-	2
	CO2	3	3	2	2	2	1	2	-	-	-	1	2
	CO3	3	3	2	2	3	-	1	-	-	1	-	2
	CO4	3	2	2	3	2	1	1	-	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC301	**PROCESS CALCULATIONS**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (CT) and End Sem Assessment (EA)					
Nil		CT+EA					
Course Outcomes	• CO1: Learn fundamentals of units and dimension, dimensionless groups and their implications. • CO2:Graphical interpretation of experimental data, use of log-log and semi log plots for non-linear equations • CO3:Understanding of mass and energy balance for various chemical processes • CO4:Understanding the Ideal gas equation, Raoult's law, Henry's law, and psychrometric property						
Topics Covered	**Module - I** Units and dimension, Dimensionless groups and their significance, Dimensional homogeneity and analysis: Buckingham's pi theorem and its application, repeating variables, Rayleigh methods, Stepwise methodology Adiabatic Flame Temperature and its importance, Energy balance in thermal reactor, Computation of AFT, effect of temperature and pressure Basic understanding of application of semi-log and log-log graph, Unit operation and experimental data fittings in log-log and semi-log graph paper, Problem-solving techniques [9 hrs.] **Module - II** Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial volume, Dalton's law and Amagat's law and Numerical problems on their applications Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications, Numerical problems on Duhring& Cox plots. Ideal& non-ideal solutions, Raoult's law, Henry's law and their applications in numerical problems. [8 hrs.] **Module - III** Concept of Material balance, basis of calculation, bypass and recycling operation, various problems on material balance- drying, evaporation, crystallization, leaching. Material balance with chemical reaction. Atmospheric air and its composition, the property of moist air and ideal gas law, Humidity and its significance, various humidity/saturation terms like molar, absolute, relative & percentage saturation Fundamental concept of dry-bulb, wet-bulb, adiabatic saturation temperatures, and dew point. Psychometric/humidity chart and its application							

	Humid volume, enthalpy and specific heat of moist air, humidification and de-humidification operation and material balance. Theoretical analysis and Energy balance during adiabatic saturation and wet bulb temperature [13 hrs.] **Module - IV** Energy conservation laws, Energy balance, Laws of thermodynamics with examples, Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, Estimation of Heat Capacities: liquids and gases. Heat of fusion and vaporization. Enthalpy calculation for systems with Chemical Reaction, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Kopps rule Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Application of Energy balance to problems of various chemical processes [12 hrs.] • **Tutorial on above topics and class tests (14)**
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Basic Principles and Calculations in Chemical Engineering – David Himmelblau, PHI <u>Suggested Reference Books:</u> 1. Chemical Process Principles – Hougen and Watson, Part-I, CRC Press, CBS. 2. Stoichiometry-4thedn, Bhatt and Vora, Tata Mc-Graw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3		3						3	
CO2	3		3		3						3	
CO3	3	3			3							
CO4	2	2	2		2			3	3	3	2	

<table>
<tr><th colspan="9">Department of Chemical Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC302</td><td>CHEMICAL ENGINEERING THERMODYNAMICS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Apply the laws of thermodynamics to chemical engineering processes and conversion devices.
• CO2: Calculate thermodynamic properties using equations of state, charts and tables.
• CO3: Apply the concept of phase equilibrium to multi-phase systems.</td></tr>
</table>

	• CO4: Solve problems of single and multi-phase chemically reactive systems using the concept of chemical reaction equilibrium.
Topics Covered	**Module - I** Scope of thermodynamics and fundamental concepts. Microscopic and microscopic view. First law of thermodynamics: Applications to batch and flow systems. Second and third law of thermodynamics: Reversibility and irreversibility, Carnot cycle, entropy, free energies, exergy [5 hrs.] **Module - II** Real gases: Equations of state, compressibility charts, departure functions Thermodynamics of flow processes: Single and multi-stage compression, expansion through nozzles. Refrigeration and liquefaction of gases: Vapour compression, cascade, absorption and gas refrigeration cycles, Choice of refrigerants, Linde and Claude processes of liquefaction of gases. [9 hrs.] **Module - III** Thermodynamic property relations: Maxwell's relations and thermodynamic functions of pure substances. Residual properties, fugacity. [5 hrs.] **Module - IV** Solution thermodynamics and phase equilibrium: Multi-component gaseous systems and solution. Partial molal properties and thermodynamic potential, criteria for equilibrium, thermodynamic properties of solutions, Gibbs-Duhem equation and consistency of thermodynamic data. Activity and activity coefficient, estimation of activity coefficient- Margules and Van laar equations, ASOG and UNIFAC methods. Generation of VLE data. Calculation of bubble and dew points of ideal and non-ideal solutions. Azeotropes. systems. Phase equilibrium at elevated pressure. [12hrs.] **Module - V** Chemical reaction equilibrium: Estimation of equilibrium constant. Homogeneous reactions. Heterogeneous reactions. [9hrs.] Tutorial on above topics and class tests. [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill) 2. Chemical Engineering Thermodynamics – G. N. Halder (Prentice Hall of India) SuggestedReference Book: 1. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley) 3. Applications of Thermodynamics, V. Kadambi , T. R. Seetharam, K. B. Subramanya Kumar, Wiley (2019)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Chemical Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC303</td><td colspan="2">FLUID MECHANICS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods [Continuous (CT) and end assessment (EA)]</td></tr>
<tr><td colspan="3">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: Create a fundamental understanding of fluidstatistics kinematicsandkinetics
CO2: Apply mass,momentumandenergy balance to hydrostatic and fluid flow problems
CO3: Acquire knowledge of Fluid machineries and flow measuring devices</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Module - I
Fluids and fluid properties, continuum concept, Fluid statics: Pressure and pressure measuring devices, Fluid kinematics, different flow regimes, equation of continuity. Boundary layer, Skin and form friction. [6 hrs.]
Module - II
Bernoulli’s equation, Hagen-Poiseuille equation, Fanning’s equation and their applications
Pipes, fittings and valves. Pressure losses due to sudden expansion, contraction and fittings
Navier-Stoke’s equation and total energy balance equation
Turbulent flow, Reynold’s stress, universal velocity profile [16 hrs.]
Module - III
Flow past solid surface, drag, flow through packed bed, fluidization, pneumatic conveying
Flow of compressible fluids, flow through convergent-divergent nozzles
Non-Newtonian fluids: Their characteristics and calculation of pressure drop due to their flow through pipes
Flow measuring devices: Orificemeter, venturimeter, rotameter, weirs, anemometer, pitot tubes, etc. [11hrs.]</td></tr>
</table>

	Module - IV Fluid machineries: Pumps, blowers and compressors [10hrs.] Tutorial on above topics and class tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Unit Operations – McCabe W L and Smith J L (McGraw Hill) 2. Transport Processes and Unit Operations – GeankoplisJ G, Allen A H, Lepek D H (Prentice Hall) Suggested Reference Books: 1. Principle of Unit Operations – Foust A S, Wenzel L A, Curtis W, Maus L, Anderson L B (Wiley)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 331	**CHEMISTRY - II**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Engineering Chemistry CYC 01		CT+MT+EA					
Course Outcomes	• CO1: To learn advanced analytical techniques useful for chemical engineering. • CO2: To learn the few catalytic process commonly used in industrial applications. • CO3: To learn thermodynamics of solutions and understanding of phase diagrams of single and multicomponent systems. • CO4: To learn fundamentals of fats, oils and carbohydrate chemistry together with basics of large scale organic synthesis.						
Topics Covered	**Module - I** Organic Chemistry Organic C-C bond formation: application of Grignard reagents, ethyl acetoacetate and malonic esters. Principles of large scale organic synthesis having industrial importance.						

	Carbohydrate chemistry: Classification, structure elucidation. Reactions of glucose and fructose; mutarotation, inversion of cane sugar. Fats and oils, soaps and detergents.[11 hrs.] **Module - II** Inorganic Chemistry Application of coordination compound in analytical chemistry: complexometric titration, biological application. Analytical methods used to metal ions estimation: Gravimetric, UV-Vis spectrophotometric, atomic absorption spectrometric, solvent extraction etc. Catalyst: General principles, homogeneous catalysts: hydrogenation of alkenes, hydroformylation, methanol carbonylation, Wacker oxidation of alkenes etc. Heterogeneous catalyst: hydrogenation catalysts, ammonia synthesis, alkene polymerisation (Zigler Natta catalyst). [11 hrs.] **Module - III** Physical Chemistry Thermodynamic condition of chemical equilibrium, Chemical potential, Activity, Fugacity, Gibbs-Duhem equation, Duhem-Margulesequatuion. 1st and 2nd order transition. Transition state theory towards rate of elementary chemical reaction, salt effect on rate of a chemical reaction. photochemical and photophysical processes, Jablonsky diagram. Phase rule and its derivation, phase diagram of CO_2, H_2O and Sulphur system, two component system, solid-liquid and binary liquid mixture, fractional distillation, steam distillation, azotrope, ideal and nonideal solution, Routs law and Henrys law, Colligative properties. Conductance and tansport number, Buffer solution, Debye-Huckel limiting law, Salt effect and common ion effect on solubility of weak electrolytes. Ion-solvent and ion-ion interaction. Electrochemical cell with transference: liquid junction potential. [15 hrs.]
Text Books, and/or reference material	<u>Suggested Text Books:</u> (i) Organic Chemistry: R.T. Morrison and R.N Boyd, Prentice Hall of India Pvt.Ltd. (ii) Inorganic Chemistry Part-I & II, R. L. Dutta (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford (iv) Physical Chemistry by P. Atkins, Oxford (v) Physical Chemistry by G.W Castellan <u>Suggested Reference Books:</u> (i) Organic Chemistry by Volhardt (ii) Fundamentals of Analytical Chemistry By Skoog, West, Holler and Crouch (iii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	2	2	1	3	2	3

CO2	3	3	3	3	3	3	3	3	1	3	3	3
CO3	3	3	3	3	2	2	1	1	1	3	2	3
CO4	3	3	3	3	3	3	3	3	1	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemistry</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYS 381</td><td>CHEMISTRY – II LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">CYS 51</td><td colspan="6">CT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To learn advanced chemical analysis useful for chemical engineering.
• CO2: Estimation of metal ion concentration using advanced spectroscopic techniques.
• CO3: Advanced synthesis and characterization methods for few compounds of industrial importance.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Determination of CMC of a surfactant: conductometrically and surface tension measurement.
2. Potentiometric titration: estimation of Fe^{2+} in Mohr's salt.
3. Determination of solubility product of lead iodide.
4. Kinetics of ester hydrolysis.
5. Spectroscopic Estimation of metal ion: Estimation of Cu^{2+}/ Cr^{3}
6. Estimation of metal ion: Estimation of Na^{+}, K^{+}, Ca^{2+} by Flame photometry
7. Estimation of base content of commercially available antacid and acid content of vitamin C.
8. Synthesis of Mohr's salt.
9. Synthesis of paracetamol.
Analysis of pyrolusite ore.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1.Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall
2. Practical Chemistry by R.C. Bhattacharya
<u>Suggested Reference Books:</u>
1. Selected experiments in Physical Chemistry by N. G. Mukherjee
2. Advanced Physical Chemistry Experiments: by Gurtu&Gurtu
3. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V. K. Ahluwalia and S. Dhingra</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	3	2	3	3	2	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3
CO3	3	2	3	3	3	2	2	2	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHS 351	**CHEMICAL ENGINEERING COMPUTING LABORATORY 1**	PCR	0	0	3	3	1.5
Pre-requisites							
Process calculations, Fluid mechanics, Thermodynamics		Viva-Voce					
Course Outcomes	• CO1: To solve chemical Engg. problems using computers • CO2: To use mathematical methods to solving chemical engineering problem						
Topics Covered	**Module I** 1. Familiarization of programming environment and execution of sample programs 2. Expression evaluation 3. Conditionals and branching 4. Iteration 5. Functions 6. Arrays [9 hrs.] **Module II** Solution of liner and non-liner algebraic equations System of linear and non-liner algebraic equations [9 hrs.] **Module III** Initial value ODES using Euler explicit and implicit technique. Non-linear ODEs System of Linear ODEs System of non-liner and Stiff ODEs. [9 hrs.] **Module IV** The problems related to chemical engineering are given as laboratory assignments. Most of the problems deals with the various numerical methods						

	taught in the Mathematics course. The problems on Phase Equilibrium, Equation of State, Determination of Bubble point and Dew Point calculation. [9 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India. 2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill. Suggested Refernce Books: 1. John H. Mathews, Numerical Methods Using FORTRAN. Prentice-Hall India 2. R. White and V. R. Subramanian, Computational Methods in Chemical Engineering.PHI.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2	2	2		2	2							2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHC401	**HEAT TRANSFER**	**PCR**	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CHC301, CHC303		CT+EA					
Course Outcomes	• CO1:Illustrate principles and laws of heat transfer of different heat exchanging phenomena • CO2**:** Solve heat transfer problems of different difficulty levels • CO3**:**Design and analyze heat transfer equipment						
Topics Covered	**Module - I** Mechanism of heat transmission: Conduction, Convection and Radiation. Conduction: Fourier's law; Steady-state heat transfer through plane wall and composite slabs, cylinders and spheres; Thermal contact resistance, Critical thickness of insulation, Optimum thickness of insulation; Unsteady-state heat transfer - use of Gurnie-Lurie chart, one and two-dimensional conduction in different geometry. [10 hrs.] **Module - II** Convection: Forced convection; Heat transfer coefficients; Overall Heat Transfer Coefficients; Log-mean temperature difference; Dimensional analysis of heat transfer; Equivalent diameter; General equation for forced convection; Thermal boundary layer; Analogy between heat and momentum transfer. [10 hrs.] **Module - III** Natural convection: Empirical equations; Condensation: Film Condensation, Derivation of heat transfer coefficient, Empirical equations; Boiling of liquids: Concept of excess temperature, Pool boiling, Forced convection boiling; Radiation: Black body and Gray body; Laws of radiation; View factor; Radiant heat exchange between surfaces [12hrs.] **Module - IV** Heat exchangers: Type of different heat exchangers and their design - Double pipe, Shell and tube, Finned tube and Compact heat exchangers; Condensers and reboilers. Evaporation: Type of evaporators with accessories; Capacity and Steam economy; Boiling point rise/elevation; Multiple effect evaporators; Design of single and						

	multiple effect evaporators. [10 hrs.] Tutorial on above topics and class Tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Process Heat Transfer: D. Q. Kern, MGH 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. SuggestedReference Books: 1. Heat Transfer: An Engineering Approach: Cengel and Boles, Tata Mc-Graw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHC402	**MECHANICAL OPERATIONS**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Fluid Mechanics		CT+MT+EA					
Course Outcomes	• CO1: Identify principles of separation of liquid-solid, gas-solid, and solid-solid • CO2: Design and analyze mechanical operation equipment • CO3: Compare performances and select type of size separation, solid-liquid separation and size reduction equipment • CO4: Learn industrial applications of size separation, solid-liquid separation, size reduction equipment						
Topics Covered	**Module - I** Particle size and shape, particle size distribution: Determination of mean particle size, Sieve analysis, Industrial screens, Effectiveness of screens Size reduction and classification of solid particles: Principles of crushing and grinding, Equipment – selection, Operating principles of Coarse crushing equipment, Intermediate & Grinding equipment, Laws of crushing and grinding – limitation and applicability Size enlargement: Granulation and other size enlargement operations. [18 hrs.]						

	Module - II Agitation and mixing: solid-solid mixture, solid-liquid paste and solution preparation, Types of equipment and power requirement, Mixing Index.[8 hrs.] **Module - III** Fluid – particles separation: Terminal settling velocity, free and hindered settling, equal settling velocity and sedimentation; Classifications and clarifications; Settling chambers, thickening, tabling, jigging, floatation, centrifugal separators, centrifuge, cyclone separators, electro-static precipitator, magnetic separator, etc. [8 hrs.] **Module - IV** Filtration: Introduction; Types of filtration; Filtration equations; batch and continuous filtration equipment – Bed, Plate and Frame, Leaf and Rotary Drum Vacuum Filters; Filter Aid and Filter Medium; Washing Conveying of solids: Bins, silo and hoppers, Conveyors and elevators, Hydraulic and pneumatic transport [10 hrs.] Tutorial on above topics and class tests [14hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. G. G. Brown, Unit Operations, CBS Publishers & Distributors, 2005 2. W. McCabe. J. Smith, P .Harriott ,Unit Operations of Chemical Engineering, McGraw Hill Education, 2017 Suggested Reference Books: 1. W.L. Badger and J. T. Banchero,Introduction to Chemical Engineering, McGraw-Hill book company, 1955 2. C.J.Geankoplis,Transport Processes and Separation Process Principles (Includes Unit Operations), Prentice Hall India Learning Private Limited, 2004 3. Richardson, Coulson and Richardson's Chemical Engineering, Volume 2, 5th Edition: Particle Technology And Separation Processes, Elsevier,2006

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3		3						3	
CO2	3		3		3						3	
CO3	3	3			3							
CO4	2	2	2		2			3	3	3	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engg</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC 403</td><td>MASS TRANSFER- I</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1 Principles of mass transfer for chemical processes
• CO2 Various laws of mass transfer and mass balance of chemical processes
• CO3 Design and analyze mass transfer equipment through problem solution</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module - I
Mass transfer operation and principles. General principles of diffusion process, Molecular and eddy diffusion in fluids, Diffusion in solids and measurement of diffusivity, Multi-component diffusion, Diffusion through a variable area, Knudsen diffusion, surface diffusion and self-diffusion [10 hrs.]
Module - II
Convective mass transfer and mass transfer coefficients: Introduction. Dimensionless groups in mass transfer and correlations for the convective mass transfer coefficient. Theories of mass transfer, Analogy between Momentum, Heat and Mass Transfer, Inter-phase mass transfer and Basic laws, Two-film theory, overall mass transfer coefficient, Material balance in contacting equipment – the operating line and Mass transfer in stage-wise contact of two phases. [10 hrs.]
Module III
Gas absorption and stripping: Introduction. Design of a packed tower: Design method based on individual mass transfer coefficients. Design method based on the overall mass transfer coefficient. Determination of the number of stages in a tray tower, HETP, Tray efficiency, Gas-liquid contacting equipment, tray or plate column, operational features of tray column: Hydraulic gradient and multi-pass trays, weeping and dumping, entrainment, flooding, turndown ratio and estimation of diameter of tray. [12 hrs]
Module IV
Elementary idea about multi-component absorption and adsorption with chemical reactions. Extraction: Liquid-liquid extraction, Equilibrium data, Use of triangular diagrams, selectivity and choice of solvent, Single and multi-stage calculation in liquid-liquid extraction. Extraction efficiency, Principles of leaching and stage calculation methods. [10 hrs.]
Tutorial on above topics and class Tests [14 hrs]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Mass Transfer Operations: R.E. Treybal
2. Principles of Mass Transfer & Separation Processes: B. K. Dutta
<u>Suggested Reference Books:</u>
1. P. Sinha and P. De, Mass Transfer Principles and Operations, PHI
2. Chemical Engineering: 5th Ed., Coulson & Richardson</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	a	b	c	d	e	f	g	h	i	j	k	l
POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1		3			2				
CO2	3		3		3					1	3	1
CO3	3		3		3		1		1		3	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 432	**MECHANICAL DESIGN OF EQUIPMENT AND COMPONENTS**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To develop a workable idea of the thermo-mechanical behaviour of industrial equipment used in various chemical industries. • CO2: To study the application of different thermodynamic principles for thermal system design • CO3: To learn the concepts of stress and strain, the properties of engineering materials, and the methods of machine design pertaining to chemical engineering						
Topics Covered	**Module – I** Relation between system and control volume approaches, Equation of states. Zeroth, first and second law of thermodynamics. Gouy-Stodola theorem; Applications of SFEE. Carnot cycle, reversed Carnot cycle, Heat engine, heat pump and refrigerators. First and second law-based performances.Properties of pure substances, Vapour power cycle—Rankine cycle. Air standard cycles—Otto, Diesel, dual and Joule-Brayton cycles. [20 hrs.] **Module – II** Review of stress, strain and deformation. Engineering materials and their properties. General principle of machine design. Factor of safety,Use of data book in mechanical design. Design of shaft and key, Mechanical drives: Introduction to simple gear drive and belt drive. Types of pressure vessels: Thin cylinder and thick cylinder. [20 hrs.]						

Text Books, and/or reference material	Suggested Text Books 1. Y. A. Cengel and M. A. Boles, Thermodynamics: An Engineering Approach, McGraw-Hill. 2. M. Zemansky and R. Dittman, Heat and Thermodynamics, McGraw-Hill. 3. V B Vhandari, Design of Machine elements [3rd edition] Suggested Reference Books: 1. M. Planck. Treatise on thermodynamics. Dover. 2. E. P. Gyftopoulos, G. P. Beretta, Thermodynamics: Foundations and applications, Dover.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1		1			1	1	3
CO2	3	3	3	1			1					3
CO3	3	3	3	1	1					2	1	3

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHS451	**FLUID MECHANICS LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
CHC 303 [Fluid Mechanics]		CE+EA					
Course Outcomes	•CO1 To prove experimentally laws/equations like Bernoulli's equation, Fanning's equation, etc. •CO2. To determine discharge coefficients of flow meters like orifice and venture meter, and velocity profiles using pitot tube •CO3. To determine K factor of pipe fittings and valves •CO4. To draw characteristic curves of pumps •CO5. To create an experimental understanding of laminar and turbulent flow regimes						
Topics Covered	1. To study different types of flow using Reynold's apparatus. 2. To verify Bernoulli's equation experimentally. 3. To determine point velocity by using Pitot tube. 4. To determine flow velocity by using Venturi meter and Orifice meter. 5. To study the flow characteristic in packed bed. 6. To study the flow characteristic in a helical coil. 7. To study the reciprocating pump characteristics.						

	8. To determine the losses due to friction in pipes and fittings. 9. Flow measurement by using V-notches [36 hrs]
Text Books, and/or reference material	<u>Suggested Text Books</u> 1. Transport Processes and Unit Operations - C. J. Geankoplis 2. Principle of Unit Operations – Foust A S, Wenzel L A, Curtis W, Maus L, Anderson L B (Wiley) <u>Suggested Reference Books:</u> 1. W. McCabe. J. Smith, P .Harriott ,*Unit Operations of Chemical Engineering*, McGraw Hill Education, 2017

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2	2	2		2	2							2
CO3	2	2		2	2							2
CO4	2	2		2	2							2
CO5	3	3		3	3							3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 452	**PROCESS EQUIPMENT DESIGN-1 (CHS 452)**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		Report submission and Viva-Voce					
Course Outcomes	• CO1: Knowledge of basics of process equipment design and important parameters of equipment design • CO2: Ability to choose material for equipment design • CO3: Ability to design pressurize vessels and various parts of vessels • CO4: Knowledge of equipment fabrication and testing methods						
Topics Covered	1. Introduction to the basic principles and criteria of pressure vessel design. 2. Unfired pressure vessels with internal and external and external pressure. 3. Introduction to standards, codes and regulations. 4. Selection of material and design of various parts of vessel 5. Design of storage vessels and their design. 6. Design of supports for vertical and horizontal towers. 7. Pipe joints and fittings, gaskets. 8. Sketching and drawing of vessel						

	9. Numerical solutions for vessel design [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Process Equipment Design by Lloyd E. Brownell & Edwin H. Young 2. Process Equipment Design by M. V. Joshi Suggested Reference Books: 1. Introduction to Chemical Equipment Design: Mechanical Aspects by B. C. Bhattacharya 2. Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus 3. Chemical Process Equipment: Selection and Design by James R. Couper

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	3	3	2	2	3
CO2	3	3	3	3	3	3	3	3	3	2	3	3
CO3	3	3	3	3	3	3	3	3	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Workshop							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Contact Hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
WSS481	**ADVANCED WORKSHOP TECHNOLOGY**	PCR	**0**	**0**	**3**	**3**	**3**
Pre-requisites WSS51 (Workshop Practices)		Course Assessment methods : Viva-voce, Checking Job, Report					
Course Outcomes	• CO1: Acquiring the skills in conventional machining operations like turning, milling and knowledge in machine tools. • CO2: Acquiring the skills in CNC machining. • CO3: Acquiring the skills in Pattern making. • CO4: Acquiring the skills in Foundry.						
Topics Covered	Machine Shop : 1) Introduction to lathe Machine. 2) Explanation of All Gear Headstock Mechanism. 3) Explanation of Norton Gearbox Mechanism with Tumbler Gear Arrangement. 4) Job on Lathe & Milling Machine. CNC Shop : 1) Introduction to Conventional Machine, NC Machine & CNC Machine with their advantages & disadvantages.						

	2) Explanation of various G Codes & M Codes. 3) Introduction to programming on CNC Lathe & CNC Milling Machine. Pattern Shop : 1) Introduction to Pattern Shop 2) Drawing Orthographic Projection of a “V Block“ Pattern using Pattern Maker Scale on a wooden board. 3) Preparation of a Wooden V Block Pattern using various carpentry tools in accordance with the previously prepared drawing. Foundry Shop : 1) Introduction to Metal Casting Process. ❖ General Foundry Safety Precautions. ❖ Process Selection of Casting. ❖ Classification of Pattern with Allowances. ❖ Tools & Equipment used in hand moulding. ❖ Organic & Inorganic Bonding agents used in moulding sand. ❖ Furnaces used for Melting. ❖ Casting Defects & their remedies. 2) Testing of Green Moulding Sand ❖ Preparation of Standard Sand Sample. ❖ Determining Moisture Content of Green Moulding Sand. ❖ To determine Green Compressive Strength of Sand Sample. ❖ To determine Green Shear Strength of Sand Sample. ❖ Determination of Permeability of Sand Sample. ❖ Mould Hardness Test. 3) Preparation of green sand mold using Split Pattern. 4) Preparation of green sand core using Split Core Box. 5) Casting of the above mould using Aluminium. 6) Foundry Tooling Design of Gate Valve Body with Selection of Parting Plane, Riser & Gating Design, Use of Chaplet, Chills & Ceramic Filters. [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Elements of Workshop Technology (Volume I and II) by Hazra and Choudhury 2. Workshop Technology by W.A.J. Chapman 3. A Course in Workshop Technology by Raghuwanshi Suggested Reference Books: 1. Principles of Foundry Technology by P.L. Jain 2. Production Technology, hmt

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	3	2	3	3	2	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3
CO3	3	2	3	3	3	2	2	2	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC501</td><td>CHEMICAL REACTION ENGINEERING</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), Mid Term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Nil</td><td colspan="5">CT+MT + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the fundamentals of chemical kinetics
• CO2: Design and analyzeideal and non-ideal chemical reactors and bioreactors
• CO3: Design and analyze the fluid-solid catalytic &noncatalytic reactors, and fluid-fluid reactors</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module - I
Review of elements of reaction kinetics: The rate expression, mechanism of reactions, Arrhenius’ equation.
Interpretation of rate data: Constant volume and variable volume batch reactors [6 hrs.]

Module - II
Single homogeneous reaction: Design of isothermal and adiabatic batch, plug flow and back mix reactors
Multiple reactions: Independent, parallel and series reactions, autocatalytic reactions. Choice of reactors for single and multiple reactions and multiple reactor systems [12 hrs.]

Module - III
Biochemical reactions: Enzyme-catalyzed and biomass growth reaction kinetics, design of bioreactors
Non-ideal flow in reactors:, residence time distribution of fluid in vessels, RTD in ideal and non-ideal reactors, modeling of non-ideal reactors [8 hrs.]

Module - IV
Solid-fluid catalyzed reactions: Catalysis, porous catalyst, steps in catalytic reactions, surface kinetics, pore diffusion resistance, performance equations, interaction of physical and chemical rate processes, effectiveness factor, selectivity, product distribution in multiple reactions, effect of pore distribution, experimental methods. Catalytic reactors
Fluid-fluid reactions: Overall rate equations, application to reactor design [9hrs.]

Module - IV
Solid-fluid noncatalytic reactions: Shrinking core model, determination of rate-</td></tr>
</table>

	controlling steps and application to design of reactors [7hrs.] Tutorial on above topics and class tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India 2. O. Levenspiel, Chemical Reaction Engineering, Wiley. Suggested Reference Books: 1. J M Smith Chemical Engineering Kinetics, McGraw-Hill Education; 3rd edition

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHC 502	**MASS TRANSFER-2**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHC 403, CHC301		CT+MT+EA					
Course Outcomes	• CO1: Understanding fundamentals of some major Mass transfer operations • CO2: Application of design principles for mass transfer devices • CO3: Learning operations of various mass transfer systems • CO4: Building foundation for process intensification • CO5:Motivation towards innovations for novel systems of mass transfer						
Topics Covered	**Module-I** Humidification & Dehumidification Operations: Principles of Humidification & Dehumidification Wet & dry bulb thermometry, Construction and use of humidity charts, characteristics of saturated and unsaturated vapor- gas mixtures, design & operation of cooling tower, Design problems [10 hrs.] **Module-II** Drying: Theory and mechanism of drying, steady and unsteady state drying, classification and selection of industrial dryers, estimation of drying rates, drying characteristics of materials, performance and design of batch and continuous dryers [10 hrs.]						

	Module-III Distillation processes: Vapor- liquid equilibrium, relative volatility, azeotropism, Equilibrium and flash distillation, types of distillation columns and construction, Rectification of binary systems, enthalpy-composition diagram and construction. [6 hrs.] **Module-IV** Rectification column design methods: Lewis-Sorel &Ponchon–Savarit, McCabe-Thiele method, Design problems [6 hrs.] **Module-V** Special distillation processes: Membrane, molecular, extractive, catalytic Distillation, multi-component Distillation & introduction to ASPEN PLUS [9 hrs.] **Module-VI** Theory of crystallization, Nucleation and crystal growth, Batch and continuous crystallizers, Design calculations for crystallizers [3 hrs.] **Module- VII** Membrane separation basics, classification, transport & exclusion mechanisms, Membrane modules and design problems on micro, ultra, nano& reverse osmosis [3hrs.] Tutorial on above topics and class Tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Unit Operations of Chemical Engineering: W.L. McCabe & J.C. Smith 2. Principles of Mass Transfer & Separation Processes: B. K. Dutta 3. Mass Transfer Operations: R.E. Treybal Suggested Reference Books: 1. Introduction to chemical engineering: W.L.Badger&J.T.Banchero 2. Membrane Science & Technology, Osada& Nakagawa 3. Industrial Water Treatment Process Technology, P. Pal, Elsevier Science 4. Chemical Engineering: Coulson & Richardson 5. Principles of Unit Operation: C. J. Geankoplis

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	2	2	2	1	2	2	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	2	1	2	2	1	3	2
CO4	3	2	3	1	2	1	1	3	2	2	3	2
CO5	3	1	2	2	2	3	1	2	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHC503	**CHEMICAL PROCESS TECHNOLOGY**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Knowledge of Unit operations and Unit processes		CT+MT+EA					
Course Outcomes	• CO1:Ability to understand the manufacturing of various inorganic and organic chemicals. • CO2: Ability to understand the process flow diagram and various process parameters. • CO3: Ability to identify and solve engineering problems during production. • CO4: Knows current scenario of chemical & allied process industries.						
Topics Covered	**Module I:** Basic philosophy of a process flow diagram (PFD). Elements of a PFD. General discussion on Influence of various parameters on deciding process for a product and method of drawing PFD. Water-sources and it's economic use. Water conditioning processes, Industrial waste water treatment - different processes Industrial production of oxygen and nitrogen, cryogenic and non-cryogenic processes. Hydrogen manufacture from different source-steam reforming and partial oxidation processes. Cement, glass, ceramic industries: Raw materials, principles of manufacture, flow-sheet [20 hrs.] **Module II:** Chlor-alkali industries: Production and consumption pattern, manufacture of Chlorine-caustic soda: Raw materials, principles of manufacture, Mercury-cathode & Membrane process: flow-sheet and sequence of operation, other processes, advancement of process technology and major engineering problems, uses. Soda-ash: Production and consumption pattern, Raw materials, Solvey process Physico-chemical principles of manufacture, carbonation and ammonia recovery step, flow-sheet and sequence of operation, other processes, advancement of process technology and modified Solvey process, major engineering problems, uses. [12 hrs.] **Module III:** Industrial Acids: Hydrochloric Acid: Raw materials, principles of manufacture, flow-sheet and sequence of operation, Sulfuric acid: sulfuric acid production process, Contact process, Physico-chemical principles and general theory of contact reaction with						

	thermodynamic and reaction engineering aspects, different types of catalyst, DCDA process, uses. Nitric Acid: Raw materials, Ostwald Process –physico-chemical principles, catalyst, process flow sheet, Phosphoric Acid: Raw materials, manufacturing process with process flow sheet [5 hrs.] **Module IV:** Fertilizer Industries: Nitrogenous fertilizers: Synthesis of ammonia- physico chemical principles, catalyst for synthesis of ammonia, process flow sheet, Urea - Raw materials, manufacturing process with flow sheet, sequence of operation, Ammonium sulphate: Raw materials, manufacturing process with flow sheet, Phosphatic fertilizers: Manufacturing process of super phosphate of lime ,triple super phosphate and ammonium phosphate, Mixed fertilizers: NPK –manufacturing process, details of major equipment.[7 hrs.] **Module V:** Organic chemical industries Oils & Fats: Methods of extracting vegetable oils, Hydrogenation of oils, major engineering problems and improved technology Soaps, Detergents &Glycerin: Classification of cleaning compounds, uses, Methods of soap production, Methods of detergent manufacture, Methods of production of Glycerin. Process description& flow sheet of each process. Sugar and starch industries: Manufacturing process with flow diagram, Sugar refining, manufacturing process of starch and their different by-products; Glucose, Sorbitol & PolyolsPulp and paper Industries, technology and manufacturing methods, world market [12hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press. 2. Austins, G.T., Sherve's Chemical Process Industries, MGH 5thEdn. Suggested Reference Books: 1. Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, IIT, Madras. 2. S. K. Ghoshal, S. K. Sanyal and S. Datta, Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi. 3. Kirk &Othmer (Ed.), Encyclopedia of Chemical Technology

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2	3		3							
CO2		2										
CO3					3							
CO4										1	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>CHC504</td><td>PROCESS CONTROL AND INSTRUMENTATION</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Knowledge of applied mathematics, Unit operations</td><td colspan="5">CE+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understanding the working principle of various measuring instruments like, level, temperature, pressure, flow and concentration etc.

CO2: Process modeling fundamentals: Differential equation models, Laplace transforms, linearization, idealized dynamic behavior, transfer functions, block diagram, and process optimization.

CO3: Evaluate stability, frequency response, and other characteristics relevant to process control.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Introduction to Instrumentation
Measurement of High temperature, Measurement of Moderate to Low Temperature, Measurement of High Pressure, Measurement of Moderate to Low Pressure, Measurement of gas and liquid flow, Measurement of multiphase flow, Measurement of liquid level & Composition [15hrs.]

Module II:
Process Dynamics & Transfer function
Process Dynamics & Model: I/O model-first-order and second-order process, Linearization and concept of deviation variable, Laplace Transform, Block Diagram, Different forcing function: step, pulse, impulse, ramp, and sinusoid. Lumped and distributed parameter system
Transfer function: SISO & MIMO systems, Transient response of first, second and higher order systems, Transportation lag; Pade approximation, Control valve: Characteristics curves and transfer function. Open loop transfer [10 hrs.]

Module III:
Closed loop systems and Stability
Closed loop systems and its components: Measuring device, Controller, Final Control Element (FCE), transmission line; Block diagram, Servo and Regulator control, closed loop response, Different type of analog controller: P, PI, PD, PID, On-Off.
Concept of Stability: BIBO, characteristics equation, Routh– Hurwitz method, root locus method.</td></tr>
</table>

	Frequency Response Analysis and Controller Tuning: Amplitude Ratio and Phase Lag calculation for: General, first, second and higher order systems, Dead time, P, PI, PD, PID controllers and their respective Bode plot &Nyquist plot; Bode &Nyquist stability criteria; [10 hrs.] **Module IV:** Controller design Empirical tuning criteria: one quarter decay ratio, ISE, IAE, ITAE. Controller tuning: Cohen-Coon, Zeigler-Nicholas method; Elementary idea of feed forward, cascade, ratio, adaptive and digital computer control. Model-based control –Internal model controller [7hrs.]
Text Books, and/or reference material	SuggestedText Book: 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. Chemical Process control, G. Stephanopoulos, PHI, 2008 3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996) Suggested Reference Books: 1. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1						1	
CO2	3	2	1								1	
CO3	3	2	1		1						1	

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 551	**HEAT TRANSFER LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods: Continuous (CT) and Viva-Voce					
Basic knowledge of heat transfer		CT+Viva-Voce					
Course Outcomes	• CO1: Apply the knowledge of fundamentals of heat transfer equipment on laboratory						

	• CO2: Experimentation and data analysis • CO3: Handling various instruments and solve various difficulty levels • CO4: Learn industrial applications of heat transfer equipment • CO5: Complete process design through assignment / group task
Topics Covered	1. Determination of overall heat transfer coefficient using plate type heat exchanger 2. Determination of overall heat transfer coefficient for drop wise & film wise condensation 3. Determination of overall heat transfer coefficient using counter flow/parallel flow concentric pipe heat exchanger. 4. Determination of boiling point elevation of aqueous salt solutions. 5. Determination of thermal conductivity of metal rod. 6. Determination of emissivity for black body and test plate. 7. Determination of overall heat transfer coefficient using shell and tube heat exchanger. [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Laboratory manual Suggested Reference Books: 1. Process Heat Transfer: D Q Kern 2. Heat Transfer: Principles and Applications: B. K Dutta

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2		3	2									
CO3			3		2							
CO4			3		2							
CO5											2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS552	**MECHANICAL OPERATION LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites							
	Viva-Voce						
Course Outcomes	• CO1 : Understand of the fundamental principles underlying mechanical operation through practical experimentation. • CO2: Know the principles of different mechanical operation equipment.						

	• CO3: Design and analyse mechanical operation equipment. • CO4: Compare performances and select type of mechanical operation equipment. • CO4: Learn industrial applications of size reduction equipment (k)
Topics Covered	1. To verify Rittinger's Law in a Jaw Crusher 2. To Study comminution through a Ball Mill and calculate its theoretical Efficiency 3. Studies on the performance of the Cyclone Separator-(I. To study the characteristics of a cyclone separator. II. To measure the fractional collection efficiency of different particle size ratio) 4. To determine overall effectiveness of a vibrating screen for a given solid sample of unknown size 5. To determine the mixing index of flour and pulses in kneader mixer 6. To determine the power consumption in a propeller mixer and compare it with the actual power requirements in agitated vessel 7. To run the operation of Plate and Frame Filter Press For filtration of calcium carbonate slurry. (I. To determine the lost quantity of calcium carbonate after filtration process.) 8. To study the influence of different flow rates of water on separation efficiency of an Elutriator 9. To determine average size of a group of particles in a mixture based on volume and surface and graphical representation of screen analysis data for size distribution of the mixture. 10. To study the working of continuous type thickener [36 hrs]
Text Books, and/or reference material	<u>Suggested Text Books:</u> Lab Manual 1. Unit Operations- G. G Brown (CBS Publishers & Distribution) 2. Introduction to Chemical Engineering-Badger and Banchero (McGraw-Hill) 3. Transport Processes and Unit Operation-C. J. Geankoplis (Prentice-Hall India) <u>Suggested Reference Books:</u> 1. Mechanical Operations for Chemical Engineers-C.M. Narayanan, B.C. Bhattacharyya (Khanna Publishers) 2. Unit Operations Of Chemical Engineering-Mc. Cabe Smith &Harriot (TMH) 3. Unit Operation-C.J. King 4. Coulson & Richardson's Chemical Engineering Volume.2

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2		3	2									
CO3			3		2							
CO4			3		2							
CO5											2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS553	**PROCESS EQUIPMENT DESIGNS 2**	PCR	0	0	3	3	3
Pre-requisites							
Heat Transfer, Process Equipment Design 1		Viva-Voce					
Course Outcomes	CO1: Ability to design Evaporator and techno-economic evaluation CO2: Ability to design Shell and Tube Heat Exchanger and selection of materials						
Topics Covered	1. Design of Multiple Effects Evaporator and techno-economic evaluation. 2. Selection of material Design of Shell and tube heat exchanger [36 hrs]						
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Process Heat Transfer by Kern 2. Coulson & Richardson's Chemical Engineering Design (Vol 6) 3. Process Equipment Design by Lloyd E. Brownell & Edwin H. Young 4. Process Equipment Design by M. V. Joshi <u>Suggested Reference Books:</u> 1. Introduction to Chemical Equipment Design: Mechanical Aspects by B. C. Bhattacharya 2. Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus 3. Chemical Process Equipment: Selection and Design by James R. Couper.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1		1							

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	**ECONOMICS AND MANAGEMENT ACCOUNTANCY**	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	• CO1: To review basic economic principles with students; • CO2: To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works; • CO3: To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.
Topics Covered	**Module I:** PART 1: Economics Group A: Microeconomics Economics: Basic Concepts Theory of Production, Cost and Firms, Analyses of Market Structures: Perfect Competition, Monopoly Market, General Equilibrium & Welfare Economics [14 hrs.] **Module II:** Group B: Macroeconomics Introduction to Macroeconomic Theory, National Income Accounting, Determination of Equilibrium Level of Income, Money, Interest and Income, Inflation and Unemployment, Output, Price and Employment. [14 hrs.] **Module III:** PART 2: Accountancy Introduction to Accounting, Financial Statement Preparation and Analysis Financial Ratio Analysis. [14 hrs.]
Text Books, and/or reference material	Suggested Text Books 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 4. Ashoke Banerjee: Financial Accounting; Excel Books 5. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 6. N. G. Mankiw: Macroeconomics, Worth Publishers Suggested Reference book 1. Dornbush and Fisher: Macroeconomic Theory 2. SoumyenSikder: Principles of Macroeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics 5. Maheshwari: Introduction to Accounting; Vikas Publishing 6. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

CO-PO MAPPING of Economics and Management Accountancy

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	3	3	3

DepartmentofChemicalEngineering								
Course Code	Title of the course	Program Core (PCR)/ Electives	TotalNumberofcontacthours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC601	**TRANSPORT PHENOMENA**	PCR	3	1	0	4	4
Pre-requisites CHC301, CHC303,CHC401, CHC403,CHC501, CHC503		CourseAssessment methods(Continuous (CT)andend assessment(EA))					
		CT+EA					
Course Outcomes (CO)	• CO1:To createan understanding on universal approach of transport phenomena and fundamental transport processeslike mass, momentum and energy. • CO2:Togivean understanding onshellbalancetechnique, setting of boundaryconditions etc.fordifferent geometryofasystem • CO3:TodevelopNSE, equation ofcontinuity, equationofenergyetc. from thefundamental conceptofconservation • CO4:To solveproblemsonmass,momentumandenergytransportusing						

Topics Covered	**Module I** Transport Phenomena: Basic concepts, fundamental transport Processes and theirrelation, transport properties, measurement of properties, boundary conditionsetc. [6hrs.] **Module II:** Momentumtransport phenomena: Shell balance technique, Derivationmomentum,velocity, shear force. in rectangular, cylindrical and spherical coordinate systems by using shell balance, Equation of continuity and change (mass, momentum & energy), Navier stokes equation (NSE), Euler equation, application of NSE in rectangular, cylindrical and spherical coordinate systems. [10 hrs.] **Module III :** Flow of fluids in thin films, parallel plates, circular tubes and annulus, adjacent flow of two immiscible fluids, couette flow, rotating surface flow and radial flow, flow near a wall suddenly set in motion.[10 hrs.] **Module IV:** Energy transport: Basic energy transport equations, derivation using elementar y volume concept and conservation theorems in different coordinate system, analysis of energy transport using hell balance techniques and basic transport equations. [8 hrs.] **Module V:** Conduction with energy sources in fixed bed catalytic reactors and in cooling fins, forced convection circular tubes, natural convection from a heated plate and unsteady state conduction of inthe slab [10 hrs.] **Module VI:** Mass transport : Types of fluxes and their relation, continuity equation for a binary mixture, boundary conditions , analysis of mass transport using shell balancetechniques andequation of continuity fordifferent coordinate systems, steadyand unsteadystate systems, diffusion in porous catalyst with and without chemical reaction, diffusion in falling liquid film, turbulent mass flux, interphasemass transport [12hrs.]
TextBooks , and/or reference material	Suggested TextBooks: 1. TransportPhenomena byBird,Stewart&Lightfoot, Wiley, 2nd Edition,2010. 2. Introduction toTransportPhenomena:Momentum, HeatandMassby BodhRaj, PHILearning, 2012 Suggested ReferenceBooks: 1.TransportPhenomena:AUnified Approachby Brodkey&Hershey,McGraw-HillChemicalEngineering Series,BrodkeyPublishing, 2003

Mapping ofCO(CourseOutcome) andPO(ProgrammeOutcome)

POs \ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2		2	2	2	2							3
CO3			2	2	3						3	3
CO4		3	3	3	3						3	3

Correlation levels1,2or3asdefined below:
1:Slight(Low) 2:Moderate(Medium) 3:Substantial(High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC602	**PETROLEUM REFINING & PETROCHEMICALS**	PCR	3	1	0	4	4
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
None			CT+MT+EA				
Course Outcomes	• CO1: Understanding technical, economic, environmental and international market issues in petroleum refining business • CO2: Understanding correlation of petroleum properties with system design and operation • CO3: Understanding design and safe operation of complex refinery units for various petroleum products • CO4: Knowledge of application of Chemical Engineering Principles in one of most relevant industrial sectors of the economy • CO5: Ignited minds with passion for innovation and sustainable development						
Topics Covered	**Module I:** Petroleum - Origin and Occurrence, Exploration, Estimation and recovery [3 hrs.] **Module II:** Evaluation of crude, Properties, testing and specifications of petroleum products [6hrs.] **Module III:** Technical, Economic, environmental and societal issuesinPetroleum Refining and marketing business. [4 hrs.] **Module IV:** Processing of Crude Petroleum: crude pre-treatment, Atmospheric and Vacuum distillation, column control schemes. [6 hrs.] **Module V:** Cracking, Reforming, Vis-breaking, Delayed Coking processes to cater to the market demand of various petroproducts, Environmental pollution associated with such processing and abatement strategies [10 hrs.] **Module VI**: Rebuilding possibilities with small molecules**:** Alkylation, Isomerization. [3 hrs.] **Module VII:** Production of finished petroleum goods like, LPG, Kerosene, Petrol, Diesel, Lubricating Oil, Bitumen, Hydro processing; Innovations and novel approaches in Hydrogen production as green fuel. [10 hrs.] **Module VIII:** Petrochemical- feedstocks, classification of petrochemicals, Cracking of raw feed stock for intermediate feed stock production, manufacture of importantpetrochemicalproducts [8 hrs.]						

Text Books, and/or reference material	Suggested Text Books: 1. Petroleum Refining Engineering: W.L. Nelson 2. Advanced Petroleum Refining: G.M. Sarkar 3. Modern Petroleum Refining: B.K.B. Rao 4. Petroleum Refining: J.P. Fauquier 5. Petroleum Refining Technology: Ram Das Suggested Reference Books: 1. Catalytic Naphtha Reforming: Sc. & Technology: G.M. Antos, A.M. Aitani, J.M. Pereira 2. Environmental Control in Petroleum Refining: J.C. Reis 3. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk 4. Petrochemicals Technology: B.K.B. Rao 5. Lubricant base oil and wax processing: AvilinoSequeira Jr. 6. Hydrocarbon Technology Journal (Center for High Technology, Delhi)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	2	2	2	3	1	3	1	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	3	1	2	2	1	3	2
CO4	3	2	2	3	1	1	1	3	2	3	3	2
CO5	3	1	2	3	2	3	1	2	3	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC 603	**PROCESS MODELLING AND SIMULATION**	PEL	3	0	0	3	3
Pre-requisites: Process calculation, Engg. Math I-III			Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))				
			CT+MT+EA				
Course Outcomes	• CO1: Understanding the principle ofmass, energy and momentum conservation equations. • CO2: Concept of steady state and unsteady state model equations • CO3: Numerical techniques to solve Algebraic, ODE and PDE (a,c,e) • CO4: Solution of various model equationsand graphical presentation (a,c,e, m)						
Topics Cove	**Module I:** Introduction to Mathematical Model and its Necessity: Empirical relationship, experimentation, data interpretation, correlation and mathematical modelling using						

red	example Model Development Principles and Classification of Models: Dimensional Analysis, Synthesis of sub-models, Experimental facts, Hypothesis, Scale up concept, Steady state, unsteady state model, dynamic response, Constitutive relationships, Deterministic and Stochastic – Macroscopic diffusion equation, Lumped and Distributed Parameter - Stirred tank and plug flow models, Linear and non-linear models Conservation principles of mass and energy and momentum balance equations and Modelling of few simple systems**,** Gravity flow tank, Flash drum, Distillation column, Double pipe heat exchanger, Gas-liquid absorption column, CSTR, Batch reactor, Plug flow reactor. **[**18 hrs.] **Module II:** Development of dynamic model, Input output model vs. state model, system parameters, numerical integration,Linear models and deviation variables, linearization of non-linear models, System with one state variables, one input. State space model, Heated mixing tank, Isothermal CSTR, Non-isothermal CSTR with 2^{nd} order chemical reaction, linearized model for the system and state space representation, Stability analysis and Eigen values. Model development of Pyrolysis, Combustion, Gasification process of coal and biomass and comprehensive modelling in TGDA, Isothermal mass loss Apparatus. [12 hrs.] **Module III:** Specialized Modeling for distributed parameter system: Distributed parameter system and model equations,the general conservation equation and interpretation of individual terms, the, Detail derivation of Finite Volume Method (FVM) and its application to steady state diffusive, convective and convective-diffusive problem. Extensions of the same for unsteady state operation, Presence of non-linear reaction terms, radiation term and linearization technique. Solution ofmodel equations. [14hrs.] Tutorial and class test [14 hrs.]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1.*Lyuben*, W.L, *Process Modelling*, Simulation and Control, McGraw-Hill, N.Y. 1990. <u>Suggested Reference books:</u> 1. Patankar, S. V., 'Numerical fluid flow and heat transfer', 1980, Hemisphere

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	1	1	2	1	2	2	1

CO2	3	3	3	2	3	2	1	3	1	3	3	1
CO3	3	3	3	2	3	2	1	3	1	3	3	1

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 651	**FUEL LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites							
		Viva-Voce					
Course Outcomes	• CO1: Demonstrate and understand the principles of fuel properties testing instrument. • CO2:Conduct the experiments for determination of properties of different fuels. • CO3:Analyze the performance of equipment through group tasks.						
Topics Covered	1. Proximate Analysis of Coal determines the moisture ash, volatile matter and fixed carbon of coal in terms of weight percentage. 2. Shattering Index of Coke 3. Caking Index 4. Swelling Index 5. Viscosity of Fuel Oils 6. Determination of Flash point and Fire point of an oil by closed cup Pensky Martin Apparatus 7. Determination of moisture content of fuel oil by Dean and Stark Apparatus 8. Aniline point determination by thin film 9. Determination of vapour pressure of petroleum products using Reid Apparatus. 10. To perform atmospheric distillation of petroleum product and to find out percent recovery, percent total recovery, percent loss, percent residue. 11. Determination of calorific value of solid fuel by Bomb Calorimeter 12. Determination of carbon residue of fuel by Conradson Method [36 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Modern Petroleum Refining: B. K. B. Rao 2. Fuels & Combustion: Samir Sarkar Suggested Reference Books: 1. Petroleum Refining Engineering: W. L. Nelson 2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2	2	2		2	2							2
CO3	2	2		2	2							2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS652	**REACTION ENGINEERING LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites							
		Viva-Voce					
Course Outcomes	• CO1:Understand the fundamental principles of reaction kinetics in different reactor through practical experimentation • CO2:Study the non-catalytic homogeneous saponification reaction in CSTR and residence time distribution in a CSTR. • CO3:Study the non-catalytic homogeneous saponification reaction in plug flow reactor. • CO4:Study the non-catalytic homogeneous saponification reaction in isothermal batch reactor.						
Topics Covered	1. Study of Non-catalytic homogeneous reaction in an Isothermal Batch Reactor. 2. Study of non-catalytic homogeneous saponification reaction in a tubular flow reactor and to interpret the kinetic data of the given reaction in the form of a rate equation. 3. Residence distribution (RTD) Studies in CSTR. 4. Study of non-catalytic homogeneous saponification reaction in a continuous stirred tank reactor and to interpret the kinetic data of the given reaction in the form of a rate equation. 5. Removal of dye using Fenton oxidation process and evaluation of its Kinetic data. 6. Study the performance of a cascade of three equal volume CSTRs in series for the saponification of ethyl acetate with NaOH. 7. Study RTD of a packed bed reactor. [36 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Laboratory Manual 2. Chemical Reaction Engineering, Octave Levenspiel , Wiley; Third edition (2006) 3. Elements of Chemical Reaction Engineering 4th Ed - H. Scott Fogler Suggested Reference Books: 1. The engineering of chemical reactions, Lanny D. Schmidt, Oxford University Press Inc; 2nd edition (2004)						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	2	2	2	1	2	2	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	2	1	2	2	1	3	2
CO4	3	2	3	1	2	1	1	3	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS653	**MASS TRANSFER LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites							
		Viva-Voce					

Course Outcomes	• CO1: To demonstrate an understanding of mass transfer modes and models • CO2: To formulate the idea of the different types of set up • CO3:To apply principles of mass transfer phenomena to chemical process industries • CO4: To enable solving the problems on process and materials related to mass transfer phenomena
Topics Covered	1. Study the characteristics of simple batch distillation 2. Determination of diffusivity of a hydrocarbon liquid through air 3. Study the performance of drying in atmospheric tray drier 4. Find out the heat transfer co-efficient for drop wise & film wise condensation 5. Study characteristics of bubble cap column 6. Determination of overall heat transfer coefficient of an open pan evaporator 7. Calculate hold up in a rotary drier 8. Experiment on flooding & loading phenomena in a packed absorption tower [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Mass Transfer: R.E.Treybal 2. Unit operations of chemical engineering: W.L. McCabe &J.C.Smith 3. Laboratory manual Suggested Reference Books: 1. Principles of Mass Transfer & Separation Processes: B. K. Dutta

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	2	2	2	1	2	2	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	2	1	2	2	1	3	2
CO4	3	2	3	1	2	1	1	3	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE610	**CHEMICAL REACTOR ANALYSIS**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term and end assessment (EA))					
CHC501		CT+MT+EA					
Course Outcomes	• CO1: Design & analyze fluid-solidnon-catalytic, catalytic and fluid-fluid reactors • CO2: Design &analyse multiphase reactors • CO3: Design and analyze bioreactors and non-ideal reactors • CO4: Analyse the thermal instability of CSTRs						
Topics Covered	**Module I:** Design and analysis of non-catalytic solid-fluid reactors [3 hrs.] **Module II:** Analysis of catalytic reactors: Packed, Moving-bed and Fluidized-bed reactors [10hrs.] **Module III:** Multiphase reactors: slurry and trickle bed reactors [9hrs.] **Module IV:** Multiple steady states and thermal instability of reactors; Dynamic analysis of CSTR; Sustained oscillation and limit cycle [5hrs.] **Module V:** Modelling of non-ideal reactors [4hrs.] **Module VI:** Biochemical reactor design [2hrs.] **Module VII:**						

	Fluid-fluid reactor design [5 hrs.] Tutorial on above topics and class tests [4hrs.]
Text Books, and/or reference material	Suggested Text books: 1. H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India. 2. O. Levenspiel, Chemical Reaction Engineering, Wiley. Suggested Reference book: 1. Chemical Reactor Analysis and Design - G F Froment& K B Bischoff (Wiley).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE611	**INDUSTRIAL POLLUTION CONTROL AND TREATMENT**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Knowledge of all Unit Operations and Unit processes		CT+MT+EA					
Course Outcomes	• CO1: The fundamental concepts in environmental engineering dealing with water, air, and land pollution. • CO2: Graduates will learn a solid foundation in mathematics, sciences, and technical skills needed to analyze and design environmental engineering systems. • CO3: Graduates will be familiar with current and emerging environmental engineering and global issues, and have an understanding of ethical and societal responsibilities. • CO4: The necessary qualifications for employment in environmental engineering and related professions, for entry into advanced studies, and for assuming eventual leadership roles in their profession.						

<table>
<tr><td>Topics Covered</td><td>Module I:
Introduction to Water Treatment: National & International Scenario; World-wide Water resources Management; Water quality standards – Drinking water standards; Industrial effluent standards [3 hrs]

Module II:
Physico-Chemical Treatment Technology: Aeration, Ion exchange, Ozone treatment, adsorption. Chemical coagulation-precipitation, settling, flocculation theorems, Chlorination, advanced scheme for municipal water treatment.[6hrs.]

Module III:
Biological Treatment: Basics of biological water treatment, relevant kinetics, biological reactor configurations, Activated sludge process, trickling filtration, lagoon treatment, submerged aerators, upward flow sludge blanket reactor, rotating disc biological contactors, advances in biological treatment. [7hrs.]

Module IV:
Membrane Treatment: Different membranes and modules in water treatment; Transport mechanisms in membrane separation; Principles of Forward and Reverse osmosis; Membrane distillation, Micro and ultrafiltration; Nanofiltration and hybrid processes in water treatment processes.[7 hrs.]
Module V:
Industry-specific advanced water treatment schemes: Petroleum refinery waste treatment, coke-oven waste treatment, pharmaceutical waste treatment, tannery wastewater treatment.[5 hrs.]
Module VI
Air Pollution
Environmental threats
Role of Atmosphere in dispersion , Plume behavior
Dispersion problems and Stack Design(Tutorial):
Control devices –Cyclone Separators, ESP, Venturi scrubber, gravity separator, filters
Design Problems (Tutorial)
Abatement of gaseous pollutants & VOCs [10 hrs.]
ModuleVII:
Solid and hazardous Waste management [4 hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td><u>Suggested Text Books:</u>
1. Industrial water treatment Process Technology, P. Pal, Elsevier Science
2. Membrane Technology in Environmental Pollution Control, P.Pal
3. Environmental Pollution Control Engineering – C.S. Rao

<u>Suggested Reference Books</u>:
1. Groundwater Arsenic remediation: Treatment Technology and Scale up, P. Pal, Elsevier Science
2. Handbook of Chlorination and Alternative disinfection, Geo. Clifford White, Wiley
3. Water Treatment Plant Design, Stephen J. Randtke, Michael B. Horsley(EDs.), ASCE
4.Water Technology, N.F. Gray, Elsevier Science</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs \ COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							3					
CO2	3	3	3			1						
CO3								3				
CO4						1			1		1	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE612	**NON-CONVENTIONAL ENERGY ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CHC401		CT+EA					
Course Outcomes	• CO1: Learn about energy technology of different conventional and non-conventional energy resource and Recent worldwide energy market scenario • CO2: Design & analyze of different renewable energy collectors and renewable energy thermal power plants • CO3: Learn industrial and domestic applications of different renewable energy sources • CO4: Solve energy technology problems of different difficulty levels through tutorials						
Topics Covered	**Module I:** Wind Energy: Sources and potentials, Wind energy conversion, General formula -Lift and Drag- Basis of wind energy conversion – Effect of density, frequency variances, angle of attack, and wind speed. Windmill rotors Horizontal axis and vertical axis rotors. Determination of torque coefficient, horizontal and vertical axis windmills, performance characteristics, Betz criteria, Design and analysis of wind turbines. geographical aspects. [10 hrs.] **Module II:** Solar Energy: Energy available form Sun, Solar radiation data, Solar energy conversion into heat, Flat plate and Concentrating collectors, Construction and performance analysis of solar flat plate collectors, Mathematical analysis of Flat plate collectors and collector efficiency, collector efficiency factor, tilt factors, collector						

	heat removal factor, Hottel-Willier-Bliss equation. Principle of Natural and Forced convection, Salt gradient solar ponds: construction, operation, technical problems, Solar drying and dehumidification: Solar cabinet dryers, convective dryers Solar engines-Stirling, Brayton engines, Photovoltaic, p-n junction, solar cells, PV systems, Stand-alone, Grid connected solar power satellite. [10 hrs.] **Module III:** Nuclear Energy: Nuclear fission principles, types of nuclear reactors (BWR, PWR, PHWR, LMCR, GCR, FFR). Nuclear reactor analysis: four factor formula, resonance absorption, reactor buckling, multiplication factor, thermal utilisation coefficient, reflector saving, fast fission factor, optimum moderator to fuel ratio. Radioactive waste disposal Energy from Ocean: Wave, Tidal and OTEC energy- Difference between tidal and wave power generation, Principles of tidal and wave power generation, OTEC power plants (closed cycle, open cycle, hybrid cycle), operation and technical problems, environmental impact, Tidal power, salinity power plants, Geothermal systems: Resources, types of wells, methods of harnessing the energy, Hot water and dry steam systems, energy extraction principles. [10 hrs.] **Module IV:** Energy from biomass: Biomass utilization: pyrolysis, gasification, anaerobic digestion (biogas production). Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, Biodiesels: Manufacture and characteristics. Gasohol: Characteristics and manufacture, use of pervaporation technology. Synthetic liquid fuels from coal: F – T Process, Coal hydrogenation, MTOG process. [10 hrs.]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1.Ashok V Desai, Non-Conventional Energy, Wiley Eastern Ltd, New Delhi, 2003 2.K M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, New Delhi, 2003. <u>Suggested Reference Books:</u> 1. Ramesh R & Kumar K U, Renewable Energy Technologies, Narosa Publishing House, New Delhi, 2004 2. Wakil MM, Power Plant Technology, McGraw Hill Book Co, New Delhi, 2004. 3. G. D. Rai Non – Conventional Energy Sources. Khanna Publication 4. S P Sukhatme and J K Nayak, Solar Energy, McGraw Hill Book Co, New Delhi 4th Edition, 2017

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="5">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>CHE 613</td><td>COMBUSTION ENGINEERING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td></td><td>3</td></tr>
<tr><td colspan="4">Pre-requisites: Process calculation, Material and energy balance, Engg. Mathematics, ODE, PDE, Numerical techniques, modelling simulation with computing skill using c and Matlab program</td><td colspan="5">Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))</td></tr>
<tr><td colspan="4"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: Clean coal technologies, coal bed methane blending of biomass with coal.
• CO2: Mass and energy balance during combustion of solid, liquid and gaseous fuel.
• CO3: Reaction kinetics and mechanism of Pyrolysis, Combustion and gasification.
• CO4: Burner design for different industrial application.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Module I:
Properties of solid liquid and gaseous fuels
Classification, Composition, Calorific Values, Lower and higher heating values, ASTM test techniques of solid, liquid and gaseous fuels.
Gasification of coal –Coal gasification technologies, chemical reactions, process conditions, design of gasification equipment. Underground coal gasification technology, process route. Clean coal Technologies:
What is clean coal technology? Principle and objectives.Oxyfuel combustion, Biochar, Carbon capture and storage, Carbon sequestration, Kyoto Protocol, Mitigation of global warming, Refined coal, Coal bed methane deposits, CBM recovery through microporous network, Primary method-Dewatering process, Secondary method (Carbon dioxide injection technique). [24 hrs.]

Module II:
Stoichiometry of combustion -
Chemical equations, Mass and energy balance of solid liquid and gaseous fuel combustion, concept of mixture fraction and equivalence ratio, problems on Fuel efficiency, excess air ratio and draft.Gas analyzers- Orsat and modern gas analyzers [7 hrs.]
Module III:
Combustion of liquid and gaseous fuels, Theory of diffusion flame, development diffusion flame equations and its solution technique, length of diffusion flame, chemical properties of diffusion flame & Premixed flame and its nature. Burner design for liquid and gaseous fuel, Types of Burners, design parameters and problems.[7 hrs.]

Module IV: 12h
Combustion of solid fuels, Stages of combustion- drying, devolatilization, volatile combustion, combustion of residual char, Pulverized coal combustion,
Combustion in fluidized bed system, burning rate in fluidized bed, factors affecting</td></tr>
</table>

	combustion efficiency. Combustion in bubbling fluidized bed boilers Combustion mechanism dense phase and lean phase concept and mass and energy balance, Recirculation of fly ash, effect of design parameters on combustion efficiency. Single particle combustion modelling- Single particle combustion modelling using volume reaction model, reaction mechanism and role of pore surface area. Heat and species transport equation in porous medium.Excremental technique in TG/DTA and drop tube furnace. [24 hrs.] Tutorial and class test [5 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Combustion and Fuel Technology, A.K.Saha 2. Combustion and gasification in Fluidized bed, PrabirBasu, Taylor & Francis Suggested Reference Books: 1. Fundamentals of Combustion Engineering by Achintya Mukhopadhyay and Swarnendu Sen

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3		3					1	3	1
CO2	3	1	1		3			2				
CO3	3		3		3					1	3	1
CO4	1	3	3		3		1		1		3	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 614	**ARTIFICIAL INTELLIGENCE (AI) IN PROCESS INDUSTRY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1 : Acquire an idea about the application of artificial intelligence in chemical process industry • CO2 : To learn the fundamental knowledge of Neural network base modeling and their application in chemical process industries • CO3: To learn the fundamental knowledge of different stochastic optimization						

	techniques and their application in industry
Topics Covered	**Module I:** Basic concept and introduction Challenges faces by process industries, Paradigm shift of chemical business, What is artificial intelligence (AI)?, What is advance data analytics (ADA)?, Use of artificial intelligence (AI) and advance data analytics in different fields, Use of AI in chemical process industry and changing business scenario of chemical process industry , Areas where AI have impact on process industry, Different real life case studies of application of AI in process industry , How AI based techniques can be used to increase profit in chemical industry. [08 hrs.] **Module II:** Application of artificial neural network (ANN) for modeling industrial processes What is process modeling? ,Difference between process design and process simulation , Different process modeling strategy , Comparative advantage and disadvantage of different modeling strategy , Limitations of first principle base modeling , Limitations of commercial simulators to model complex industrial reactors ,Data driven black box or grey box modeling technique and its advantage ,Necessity to build a platform to utilize large number of process data , Artificial neural network (ANN) as effective tool of black box modeling, What is artificial neural network (ANN)?, Network architecture, Back propagation algorithm, How ANN can be used to develop complex industrial processes, Steps in ANN modeling technique ,Modeling of process performance parameters like selectivity, yield, efficiency etc. , Different examples of ANN modeling applied in diverse field of process industries, A step by step matlab based ANN case study for modeling of industrial reactor ,Different aspects of ANN modeling**.** [12 hrs.] **Module III:** **Artificial intelligence based process optimization** What is process optimization? , How parameter optimization can increase profit? , Limitations of conventional methods to apply complex industrial context, Use of metaheuristic method for optimization, Different Meta heuristics strategies like genetic programming, differential evolution and particle swarm optimization, Genetic algorithm (GA), what is GA? Basic algorithm and matlabcode ,Explanation of different parameters in GA algorithm ,Different uses of GA in various fields of process optimization , Differential evolution (DE), what is DE? Basic algorithm and matlabcode ,Explanation of different parameters in DE algorithm,Different uses of DE in various fields of process optimization Particle swarm optimization (PSO), What is PSO?, Basic algorithm and matlab code, Explanation of different parameters in PSO algorithm, Different uses of PSO in various fields of process optimization ,How metaheuristics algorithm can be used for parameter optimization,3 case study in reactor optimization, Advantage of metaheuristics methods over conventional methods. [10 hrs.]

	Module IV: Artificial intelligence based fault diagnosis in process industry Development of system to use and generate knowledge from process data ,Online advance process monitoring ,Generation of dashboard of different KPI ,Use of different advance computational technique to visualize data ,Artificial neural network based monitoring system ,How ANN can be used to develop advance process monitoring system ,Steps to develop ANN based process monitoring system Principal component based monitoring system, What is Principal component analysis (PCA)?, PCA algorithm, How PCA can be used to develop advance process monitoring system ,Advantage of PCA based monitoring system ,Steps to develop PCA based process monitoring system Development of Fault diagnosis system What is fault diagnosis system?, Features of fault diagnosis system ,How a robust fault diagnosis system can be made by PCA and ANN , Steps to build efficient fault diagnosis system ,Matlab code ,Case study. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Profit Maximization Techniques for operating Chemical Plants, Sandip Kumar Lahiri, Wiley, ISBN 978-1-119-53215-6 2. Process plant simulations, B.V. Babu ,Oxford University Press 2004, ISBN **0-**19-566805-7 Suggested Reference books : 3. Energy and process optimization for the process industries By Frank (Xin X) Zhu (Wiley, ISBN 978-1-118-10116-2)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	2	2	2	2	2	1	1	2	1	2	2	1	2
CO2	3	3	3	2	3	2	1	3	1	3	3	1	3
CO3	3	3	3	2	3	2	1	3	1	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit	
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours		
MSC731	**PRINCIPLES OF MANAGEMENT**	PCR	3	0	0	3	3	
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))						
		CA+EA						

Course Outcomes	• CO1:To make budding engineers aware of various management functions required for any organization • CO2:To impart knowledge on various tools and techniques applied by the executives of an organization • CO3:To make potential engineers aware of managerial function so that it would help for their professional career • CO4:To impart knowledge on organizational activities operational and strategic both in nature • C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science
Topics Covered	**Module I:** Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning andenvironmental analysis with SWOT, Application of BCG matrix in organization [8 hrs.] **Module II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique [7 hrs.] **Module III:** Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. [8 hrs.] **Module IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. [8 hrs.] **Module V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit

	(CVP) Analysis, An overview of financial market with special reference to India. [12 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. 2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education Suggested Reference Books: 1. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 2. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey

Mapping of CO (Course Outcome) and PO (Programme Outcome)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	2	2	
CO2				2					2	2		
CO3				2					3	2		
CO4							1		3			
CO5				2					2	2	2	

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 751	**PROCESS CONTROL AND INSTRUMENTATION LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Process Control and Instrumentation		CT and Viva-Voce					
Course Outcomes	• CO1: Understand the fundamental principles of process control through practical experimentation • CO2: Handling various instruments and solve various difficulty levels						
Topics Covered	1. Study the control valve flow coefficient (C_v) and its inherent characteristics. 2. Study the temperature control trainer and to find out steady state process gain. 3. Study the level control trainer and to find out steady state process gain. 4. Compare the observed transient response with the theoretical transient response for the interacting – non-interacting system. 5. Study the step response of mercury manometer and water manometer.						

	6. Plot Bode diagram of manometer systems and design the controller using Z-N tuning method. 7. Study the root locus of a manometer and hence to determine the region of stability. [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 Edition (1991) 2. Chemical Process Control, G. Stephanopoulos, PHI, (2008) Suggested Reference Books: 1. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (1996)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2	1	2				1		2	
CO2	3		2	1	2				1		2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 752	**CHEMICAL ENGINEERING COMPUTING LABORATORY- 2**	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
CHEMICAL ENGINEERING COMPUTING LABORATORY- 1 (CHS 351)	EA and Viva-Voce
Course Outcomes	• CO1: To improve the skill of programming with numerical methods • CO2: To solve Chemical Engg problems using computers (using Matlab/Aspen/Ansys)
Topics Covered	**Module I** 1. Arrays Operations, Loops in Matlab 2. Script and Functions in Matlab 3. Plotting in Matlab 4. Truncation Error and Numerical error in Matlab 5. Numerical Differentiation and Integration using Matlab **Module II** Solving Linera/non-linear equations using Matlab

	Solving set of linear equation Solving ODEs in Matlab (RK/ODE45) **Module III** Intruduction to Matlab-Simulink Tuning of PID controller using Simulink Example cases using Simulink **Module IV** Introduction to Aspen-Plus Property analysis using Aspen-Plus Process Modelling and simulation using Aspen-Plus [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Computational Techniques for Process Simulation and Analysis Using MATLAB, Niket S. Kaisare, CRC Press 2. Teach Yourself the Basics of Aspen Plus, Ralph Schefflan, 2nd Edition, AIChE, Willey Suggested Reference Books: 1. Introduction to Simulink: With Engineering Applications,by Steven T. Karris, Orchard Pubns; 3rd edition

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2	1	2				1		2	
CO2	3		2	1	2				1		2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 753	**COMPUTER-AIDED PROCESS EQUIPMENT DESIGN**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Process Equipment Design I & II		Report submission and Viva-Voce					
Course Outcomes	• CO1: Students are groomed to become confident design engineers / process simulators. They are also made conversant with all aspects of chemical engineering science, since development of CAD packages demands proficiency in all unit operations and unit processes.						
Topics Covered	1. Introduction to the basic principles of pressure vessel, Heat Exchanger, Evaporator and distillation process and its applications						

	2. Computer Aided process design of Pressure Vessel by Auto-CAD 3. Computer Aided process design of Heat Exchanger column by Auto-CAD 4. Computer Aided process design of Evaporator by Auto-CAD 5. Computer Aided process design of distillation column by Auto-CAD
Text Books, and/or reference material	Suggested Text Books: 1. L. E. Brownell, E. H. Youg, "Process Equipment Design" John Wiley & Sons Publications, 2004. 2. J.M. Coulson and J. Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers Ltd. 3. Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, 1969. Indian Standards Institution, New Delhi. Suggested Reference Books: 1. R.H. Perry, "Chemical Engineers' Handbook", McGraw-Hill. 2. W.L. McCabe, J.C. Smith and P. Harriot, "Unit Operation of Chemical Engineering", McGraw-Hill, 2001.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	3	3	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS754	**VOCATIONAL TRAINING / SUMMER INTERNSHIP & SEMINAR**		0	0	2	2	1
Course Outcomes		• CO1: Ability to understand all the Unit Operations and Unit Processes in real-life problem. • CO2: Knowledge sharing (h)					
Topics Covered		Industrial Training, Internship etc. 4 -8 weeks					
Text Books, and/or reference material		NA					

Seventh Semester Departmental Electives (CHE710-719)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHE 710</td><td>ENERGY SOURCES AND UTILISATION</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Learn different sources of energy and basic terminology
• CO2: Identify characteristic properties of fuels and analyze fuel processing equipment
• CO3: Compare performances and select type of fuel processing equipment</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Introduction: Survey of different sources of energy and their utilization.
Fossil fuels: Coal, Petroleum and gaseous fuels.
Coal: Origin and formation of coal . Petrographic constituents of coal, Properties and testing. Classifition of coal, Coal preparation- washing and blending, Metallurgical and other uses. Carbonisation of coal, coke ovens and recovery of by-products. [5 hrs.]
Module II:
Petroleum : Constitution of petroleum, Origin and Occurrence of crude, Evaluation of crude, Properties, testing and specifications of petroleum products- Octane no.; Reid vapor pressure; Flash point; Fire point; Smoke point; Pour point; Cloud point; Aniline point and Diesel index; Cetane no. , Processing of Crude Petroleum.[12hrs.]
Module III:
Gaseous fuels: Classification. Manufacture of producer and water gas.
Combustion and furnace: Combustion characteristics, Combustion appliances--furnaces, waste heat recovery system, burners. [11 hrs.]
Module IV:
Non-conventional energy sources: Solar energy, Wind, Tidal Energy, Wave Energy, Energy from biomass, [4 hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Modern Petroleum Refining: B. K. B. Rao
2. Fuels & Combustion: Samir Sarkar
<u>Suggested Reference Books:</u>
1. Petroleum Refining Engineering: W. L. Nelson
2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk
3. The elements of fuel technology: G. W. Himus</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 711	**BIOPROCESS & BIOREACTOR ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHC 301, CHC 403, CHC501		CT+MT+EA					
Course Outcomes	• CO1: Apply kinetics of biochemical reactions for design of bioreactor. • CO2: Analyze performance of ideal and non-ideal bioreactors. • CO3: Integrate different type of reactor and reactor assembly.						
Topics Covered	**Module I:** Introduction to the kinetics of Bioprocess; Free enzyme kinetics; Inhibition in enzymatic reactions. Kinetics of immobilized enzymes. Bioreactors for enzymatic reactions. [15 hrs.] **Module II:** Cell growth kinetics; Growth models, Inhibition in cell growth kinetics, Immobilized cell growth system. Reactors for cell growth system. Combination of bioreactors for cell growth. [15 hrs.] **Module III:** Multiplicity in Biosystems, Global and local stability analyses of Bioreactors. Bioreactor controlling probes, Characteristics of bioreactor sensors, Temperature measurement and control, DO measurement and control, pH/redox measurement and control, Detection and prevention of the foam. [10 hrs.] **Module IV:** Downstream processing in bioprocesses; Intra and extracellular product extraction and separation. Industrial application of bioprocesses. [10 hrs.]						

Text Books, and/or reference material	Suggested Text Books: 1. J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, Second Edition, Mc. Graw Hill Inc., Singapore, 1986. 2. H. W. Blanch, D. S. Clark, Biochemical Engineering, Special Indian Edition, Marcel Dekker Inc. New York, 2007. 3. M. L. Shuler, F. Kargi, Bioprocess Engineering - Basic Concepts, Second Edition, Prentice Hall of India Private Ltd., New Delhi, 2002. Suggested Reference Books: 1. P. M. Doran, Bioprocess Engineering Principles, Academic Press, California, 2009. 2. J. Nielsen, J. Villadsen, G. Liden, Bioreaction Engineering, Second Edition, Springer, 2007. 3. D. G. Rao, Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	1	1	2	2	2	3	1
CO2	3	2	3	2	3	1	1	2	2	2	3	1
CO3	3	2	3	2	3	1	1	2	2	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 712	**PROCESS ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites Unit operations and Chemical reactor, Chemical Process Technology, Optimal design methods		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Understanding process design concepts • CO2: To troubleshoot real-time chemical processes • CO3: To do optimal plant operation						
Topics Covered	**Module I:** Introduction Course objectives and course outcomes- Definition of process engineering– responsibilities of Process Engineers. Structure of Processes and Process Engineering [5hrs.]						

	Module II: Process Design and Flow sheeting, Process design principles; process selection; Degree of freedom; selection of design variable; mass balance and energy balance; process flow sheeting; sizing of equipment. [12hrs.] **Module III:** Process dynamics and dynamic optimization: Process response and retrofitting; Dynamic models; Optimization models for process synthesis and design; dynamic optimization; real-time optimization;[12hrs.] **Module IV:** Process Synthesis : Basic concepts in process synthesis; flowsheet optimization and economic analysis; process trouble shooting; case studies, [12hrs.]
Text Books, and/or reference material	SuggestedText Books: 1. Rudd DF, Watson, CC. Strategies of process engineering, John Wiley, 1968 2. Seader WD, Seader, JD, Lewin, DR. Product & process design principles, John Wiley, 2004 Suggested Reference Books: 1. Arthur W. Westerberg, I.E. Grossmann, and Lorenz T. Biegler, Systematic Methods of Chemical Process Design. Prentice Hall

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1	1						1	
CO2	3		2								1	
CO3	3				1							1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE713	**CHEMICAL PLANT DESIGN AND ECONOMICS**	PEL	3	0	0	3	3
Pre-requisites: Unit operations and Chemical reactor, Chemical Process Technology, Optimal design methods		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1:Managing various process design projects						

	• CO2: Understanding process design concept based on mass-energy balance and optimization • CO3: Determining design-project feasibility and implementation time
Topics Covered	**Module I:** Plant Design life cycle: Various stages of a plant design project – managing the various stages of plant design project – various approaches. Various scheduling methods for plant design[10hrs.] **Module II:** Plant Design Projects: Process design principles; process selection-DOF-design variable; -mass balance and energy balance; flowsheeting; sizing of equipment; P&ID-basic engineering package (BEP); Principles of equipment layout in and site selection for chemical plants; Types and selection of materials of construction for process equipment. [12 hrs.] **Module III:** Feasibility of Plant Design **:** Estimation of cost and profit - taxes & depreciation-rate of return (ROI)-case studies; Screening of Process Alternatives; Concepts of investment, interest and time value of money; Profitability analysis. Analysis of alternative investments and replacements.[10hrs.] **Module IV:** Case studies : Design of Reactors; Design of Separation Processes; Energy Integration and Design of Heat Exchanger Network (Pinch Technology);[13 hrs.]
Text Books, and/or reference material	<u>SuggestedText Books</u>: 1. Peters, M S, Timmerhaus, KD, Plant Design and Economics, McGraw Hill, 1991 2. Towler G, Sinnott, Ray, Chemical Engineering Design, Elsevier, 2008 <u>SuggestedReference Books:</u> 1. Rudd DF, Watson, CC. Strategies of process engineering, John Wiley, 1968 2. Seader WD, Seader, JD, Lewin, DR. Product & process design principles, John Wiley, 2004.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1							1	1
CO2	3				1						1	1
CO3	3			1	1						1	1

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 714	**PROCESS SAFETY IN CHEMICAL INDUSTRIES**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Understand the key principles of process safety and its management and consequences of poor process safety (human, environmental and business consequences) • CO2: Understand the hazards associated with process plant and how the risks can be controlled • CO3: Understand the key process safety requirements at each stage in the life cycle of process plant from conceptual design through to operation, maintenance and modification • CO4: Understand the interdependence and the need for overall organization process safety management capability						
Topics Covered	**Module I:** Introduction and Review of Industry Accidents, Basic Laboratory Safety and Bio-safety levels, Importance of personal protective equipment,[8 hrs.] **Module II:** Basics of process safety management , Toxicology and Industrial Hygiene, [7 hrs.] **Module III:** Source Models and Dispersion Models, Fire and Explosion, Designs to prevent fire Fire extinguishers and Sprinklers Introduction to reliefs. [20 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Process Safety: Fundamentals with Applications: Daniel Crowl and Joseph F. Louvar, 3rd ed., Pearson New International Edition. Suggested Reference Books: 1. Safety in Chemical Plants/Industry & its Management, B. K. Bhaskara Rao, R. K Jain, Vineet Kumar, Khanna Publishers						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3	1	2	3		2	1	3	3	2
CO2	3		3	1	2	3		2	1	3	3	2
CO3	3		3	1	2	3		2	1	3	3	2
CO4	3		3	1	2	3		2	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC 715	**MEMBRANE SEPARATION PROCESS**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHC 502		CT+MT+EA					
Course Outcomes	• CO1: Learn fundamentals of membrane separation processes and current market scenario • CO2: Classify and characterize membrane separation processes • CO3: Principles and methodologies of separation and transport of molecules through membrane and latest development • CO4: Complete process design of separation and exercise problems through tutorials/ assignment / group task							
Topics Covered	**Module I:** Membrane Separation Processes: Types of membranes and membrane characterization, Membrane modules and motion of molecules through membrane, Classification & characterization of Membrane Separation Processes. Reserve Osmosis (RO): Fundamentals, Osmotic Pressure, Models of Solvent and solute Transport through membrane – Fluxes, Rejection and Separation factor, Mechanism of salt rejection by CA membrane, Concentration Polarization, applications [12 hrs.] **Module II:** Nano-filtration (NF): Fundamentals of NF, Models and Types of transport mechanism in NF membranes, Applications of NF Ultra-filtration (UF): Models and Types of transport in UF membranes, Membranes for UF – Fouling and concentration Polarization in UF, Separation schemes using UF, Dia-filtration – process design – batch, continuous, multistage Micro-filtration (MF): Membranes for MF – transport mechanism [12 hrs.] **Module III:** Dialysis: Solute transport in dialyzer – analysis of dialysis operation, Mode of dialysis, Hemo-dialysis – dialysis equipment – applications Electro –dialysis (ED): Types of ED – ion transport fundamentals, Resistances and voltages in ED cells – power requirement, ED membranes and cells, Problems of ED operation, Plant design and process cost. [8 hrs.] **Module IV:** Pervaporation (PV): Theory of PV – parameter study, Classification of PV – air heated							

	PV, Osmotic distillation, thermo-pervaporation, Advantages and disadvantages of PV, Application of PV, Gas Separation: Membrane gas separation, Industrial applications. [8 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Separation Processes – C. J. King 2. Synthetic membranes – P. M. Bungay, H. K. Lonsdale, M. N. de Pinho Suggested Reference Books: 1. Membrane Separation Processes – KaushikNath 2. Membrane Hand Book – W. Ho and K. K. Sirkar 3. Industrial Processing with membranes – R. E. Lacey & S Loeb 4. Reverse Osmosis – S. Sourirajan 5. Ultrafiltration Handbook – M. Cheryan 6. Principles of Mass Transfer and Separation Processes – B. K. Dutta 7. Membrane Technology in Environmental Pollution Control, P.Pal 8. Industrial Water Treatment Process Technology, P.Pal, Elsevier Science 9. Membrane Technology in Environmental Pollution Control. P.Pal

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	2	2	2	1	2	2	1
CO2	3	2	3	2	2	1	1	2	1	2	2	2
CO3	3	2	3	2	2	2	1	2	2	1	1	2
CO4	2	3	2	1	2	1	1	3	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 716	**PROCESS INTENSIFICATION**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Understanding the concept, need and benefits of process intensification amidst • stringent environmental regulations, concerns for energy security and sustainable • development • CO2: Learn different approaches of achieving process intensification • CO3: Learning design, operation, analysis and application of selected process intensification technologies						

Topics Covered	**Module I:** Basics of Process Intensification, definitions, routes, benefits, need for process intensification, sustainable development issues [4 hrs.] **Module II:** Twelve principles of green chemistry. Matrices for chemistry: Effective mass yield, carbon efficiency, atom economy, reaction mass efficiency, Environmental factor (E) [4 hrs.] **Module III:** Process Intensification by Multifunctional equipment, Principles, design, operation and case studies [4 hrs.] **Module IV:** Process Intensification by reactive distillation: Principles, design, control, feasibility, technical evaluation, case studies [4 hrs.] **Module V:** Process Intensification by catalytic distillation: Principles, design, operation, application, economics [4 hrs.] **Module VI:** Process Intensification by Membrane application: principles, modular design issues, energy saving prospects, space-saving prospects, green processing prospects, case studies [4 hrs.] **Module VII**: Case studies of process intensification in lactic acid manufacture, glutamic acid manufacture, industrial wastewater treatment and reuse, recovery of valuables. [6hrs.] **Module VIII:** Process Intensification through cavitation reactors, oscillatory baffled reactors, sono-chemical, hydrodynamic cavitation reactors, case studies [4 hrs.] **Module IX:** Process Intensification through monolith reactors: Hydrodynamics, design, advantages, applications [4 hrs.]
Text Books, and/or reference material	Suggested Text Book: 1. Intensification of bio-based processes, A. Gorak, Andrzej Stankiewicz edited. RSC publication 2. A.Stankiewicz, J.A. Moulijin, Re-engineering the Chemical Processing Plant, Process intensification, Marcel Dekker, New York (2004) Suggested References Book: 1. Membrane based technologies for environmental pollution control, P.Pal, Elsevier Sci.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 717	**COLLOIDS AND INTERFACE ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Acquire an idea about the application of colloidal chemistry, fluid-fluid and solid-fluid interface engineering in different industrial fields. • CO2: To learn the fundamental knowledge of intermolecular forces involved in colloids and interfaces • CO3: Introduction to surface active agent and learn about the application of surface active agents to enhance the efficiency in the process.						
Topics Covered	**Module I:** Importance and scope of the subject. Overview of colloidal systems, interfaces and surface. Properties and application of the colloids. Colloidal stability factor. Kinetic theory of colloidal systems: sedimentation, centrifugation, diffusion, Domestic and industrial application of colloidal solution. Adsorption at fluid-fluid and fluid-solid interface, Thermodynamics of interfaces, Interfacial rheology and transport process.[10hrs.] **Module II:** Surface active agent: Surfactant, Surface and interfacial tension, surface free energy. Surface tension for curved interfaces, Surface excess and Gibbs equation. Theory of surface tension, contact angle, and wetting. Thermodynamics of micelle and mixed micellar formation. Adsorption of single and mixed surfactants at interfaces, Mixed micellar properties, Rheology of surfactant systems. Preparation, mechanistic details of stabilization and relationship between HLB and solubility parameter, characterization and Application. [10hrs.] **Module III:** Intermolecular forces relevant to colloidal systems: Electrostatic and van der Waals forces. DLVO theory.Measurement techniques of surface tension, contact angle, zeta potential, particle size.[4 hrs.] **Module IV:** Overview of industrial applications of various interfacial phenomena in the industries [Mattress industry (Foam: preparation, characterization, stability), petroleum industry, Mineral processing industry Pesticides, firefighting, personal care						

	formulations], Super hydrophobic surface and self-cleaning surfaces. Case studies related interfacial science. Application of interfacial engineering concept through the surface modification for the synthesis of nanostructured material by using surface active agent.[12hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. P. C. Hiemenz, and R. Rajagopalan, Principle of colloid and surface chemistry, 3rd edition, MercelDekher, N. Y. 1997. 2. Pallab Ghosh, Colloid and Interface Science, 1st Edition, PHI Learning, 2009. 3. M. J. Rosen, Surfactants and Interfacial Phenomena, Wiley-Interscience Publication, New York, 2004. Suggested Reference Books: 1. Drew Myers, Surfaces, Interfaces and Colloids, 3rd Edition, Wiley, 2006. 2. Tharwat F. Tadros, Applied Surfactants Principles and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2005. 3. J. Israelachvili, Intermolecular and Surface Forces, Academic Press, New York, 1992.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3							2				1
CO2			2		2							1
CO3		2	2					2				

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 718	**PINCH TECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Heat Transfer		CT+EA					
Course Outcomes	CO1: Identify the minimum heating and cooling requirements for a process based on thermodynamic knowledge. CO2: Evaluate lower cost solutions for arrangements of heat exchangers. CO3: Design optimal heat exchangers networks to improve energy recovery and global energy efficiency of processes.						
Topics Covered	**Module I:** Introduction to process Intensification and Process Integration (PI). Areas of						

	application and techniques available for PI, onion diagram. **Introduction to Pinch Technology, Concept** of ΔT_{min}, Data Extraction, Composite curve, Grand Composite Curve Targeting, Grid Diagram, Problem Table Algorithm. [4 hrs.] **Module II:** Energy Targeting, Area Targeting, Number of units targeting, Shell Targeting and Cost targeting. [8hrs.] **Module III:** Pinch Design Methods of HEN, Heuristic rules, stream splitting, and design of maximum energy recovery (MER). Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems and design strategy. Network evolution and evaluation-identification of loops and paths, loop breaking and path relaxation. [10hrs.] **Module IV:** Design tools to achieve targets, driving force plot, remaining problem analysis, diverse pinch concepts, MCp ratio heuristics. Targeting and designing of HENs. [4 hrs.] **Module V:** Case studies on heat integration by pinch technology. [8hrs.]
Text Books, and/or reference material	Suggested Text Books: **1.** Ian C. Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, 2nd Edition, ISBN: 9780750682602, Butterworth-Heinemann, 2016. **2.** Shenoy U. V.; "Heat Exchanger Network Synthesis", Gulf Publishing Co. **3.** Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. Of Chemical Engineers. Suggested Reference Book: **1.** Smith R.; "Chemical Process Design", McGraw-Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	2	-	-	-	-	-	-	-
CO2	3	2	3	2	3	-	-	-	-	-	-	-
CO3	3	1	3	3	3	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 719	**ENERGY MANAGEMENT AND PROCESS**	PEL	3	0	0	3	3

	OPTIMIZATION IN CHEMICAL INDUSTRIES						
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire an idea about the energy intensity in industry context and benchmarking energy intensity • CO2: To learn the step by step methodology for energy assessment in industry, finding optimization opportunities and how to exploit them in industry. • CO3: To learn the fundamental knowledge of different Process optimization techniques to increase profit						
Topics Covered	**Module I:** Basic concept and introduction Challenges faces by process industries ,Paradigm shift of chemical business ,Background of energy and process optimization in industry ,Five ways to improve energy efficiency , Four key element for continuous improvement , Theory of energy intensity ,Definition of process energy intensity ,Concept of fuel equivalent ,Energy intensity for a total site, Benchmarking energy intensity, Data extraction from historian ,Convert all energy usage to fuel equivalent ,Energy balance, Energy performance index method ,Key indicators and targets ,Define key indicators, Set up targets for key indicators, Economic evaluation of key indicators ,Implementing key indicators into energy dashboard. [10hrs.] **Module II:** Pinch Technology for heat exchanger network, Basic concept of pinch, Hot and cold composite curve, Pinch temperature, Golden rules of pinch, cross pinch heat transfer, Minimum hot and cold utility target, Optimum delta T min. [12hrs.] **Module III:** Heat exchanger Distillation system performance assessment, Basic concept and calculations, understanding performance criteria –U values, understanding pressure drop,Improving heat exchanger performance, Heat exchanger fouling assessment, Fouling mechanism, Fouling mitigation, Fouling resistance calculations, A cost based model for clean cycle optimization,Energy loss assessment, Energy loss audit, Energy loss evaluations,Brainstorming, Energy audit report, Distillation system assessment Distillation operating window,Distillation efficiency,Understanding operating window,Typical capacity limit, Distillation system optimization, Define a base case,Building process simulation, Tower efficiency assessment,Tower optimization basis,Energy optimization for distillation system,Overall process optimization. [10hrs.] **Module IV**: Process optimization in industryCollect online data for the whole operation cycle, Determine the true benefit from process variation, Map the whole process in cost term,How to detect opportunities for optimization,Common tools available to exploit those opportunities. [12hrs.]						

Text Books, and/or reference material	Suggested Text Books: 1. Energy and process optimization for the process industries By Frank (Xin X) Zhu (Wiley, ISBN 978-1-118-10116-2) 2. Profit Maximization Techniques for operating Chemical Plants, Sandip Kumar Lahiri, Wiley, ISBN 978-1-119-53215-6 Suggested Reference books: 1. Process Heat Transfer – D.Q.Kern (McGraw-Hill)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	2	2	2	1	2	1	1	2	1	2	2	1	2
CO2	3	3	3	2	3	2	1	3	1	3	3	1	3
CO3	3	3	3	2	3	2	1	3	1	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EIGHTH SEMESTER

<table>
<tr><td colspan="9">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHE810</td><td>MULTIPHASE FLOW</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">CHC-303 (Fluid Mechanics)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To learn fundamental and modeling methods of multiphase flow
• CO2: To learn transport mechanism of multiphase flow and industrial application of multiphase flow
• CO3: To learn differentflow patterns and flow pattern maps and measurement methods in multiphase flow.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Introduction to multiphase flow: Two phase flow: Gas/Liquid and Liquid/liquid systems: Flow patterns in pipes, analysis of two phase flow situations, Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction. [7hrs.]

Module II:
Flow Models:Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models -correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows Introduction to three phase flow. [10hrs.]

Module III:
Design and Stability of multiphase system:Dynamics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Flow regimes, pressure drop, holdup, distributions, mass and heat transfer, reactions, Applications of these contactors. [10hrs.]

Module IV:
Measurement techniques for multiphase flow:Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry). [10hrs.]</td></tr>
</table>

	Module V: Hydrodynamics of three phase systems:An introduction of three phase flow; liquid – solid flow, gas-solid flow; liquid-liquid-gas flow; gas-liquid-solid flow; principle of hydraulic and pneumatic transportation; flow regime identification; related measurement techniques. [5hrs.]
Text Books, and/or reference material	Suggested Text Books 1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 1978. 2. Y. T. Shah, Gas-Liquid-Solid reactors design, McGraw Hill Inc, 1979 3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 1998 4. Govier, G. W. and Aziz. K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold, New York, 1972. Suggested Reference Books 1. Wallis, G.B., “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969. 2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998 3.Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003 Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York. 1998.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		1		1					1		
CO2				1				1		1		
CO3	3		1	1		1		1	1	1		

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 811	**PROCESS ANALYSIS AND OPTIMIZATION**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC01, MAC02, CHS351		CT+MT+EA					
Course Outcomes	• CO1: Conceptualization of a chemical process and its needs • CO2: Solving material and heat balance for a large-scale process • CO3: Understanding process synthesis						

	• CO4: Solving optimal design and control problems simultaneously • CO5: Real time optimization techniques and their implementations
Topics Covered	**Module I:** Cramer's rule, Inverse of matrix, Gauss elimination, Gauss Jordan method, LU decomposition, Gauss Seidel method, error analysis, Linear regression. [9hrs.] **Module II:** Bisection method, successive substitution method, Newton-Raphson method, Secant method, Eigen values, Eigen vectors and its application in solving differential equations. [10hrs.] **Module III:** Multi-variable optimization algorithms: Unidirectional search, Direct search methods, Gradient based methods, Constrained optimization algorithms: Kuhn-Tucker conditions, Transformation methods. [8 hrs.] **Module IV:** Sensitivity analysis, Direct search for constrained minimization, Linearized search techniques, Feasible direction method, Generalized reduced gradient method, Gradient projection method. [6hrs.] **Module V:** ODE- Initial Value Problem, Boundary Value Problem, Specialized algorithms: Integer programming, Geometric programming, Nontraditional optimization algorithms: Genetic algorithms, Simulated annealing, Global optimization. [5hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Steven C. Chapra& Raymond P. Canale, "Numerical methods for engineers" McGraw-Hill, Sixth Edition 2. S. K. Gupta, "Numerical Techniques for Engineers", New Age International Publishers, 3rd edition, 2015 3. Deb K., Optimization for engineering design, Algorithms and examples, Prentice Hall of India, New Delhi, 2005. Suggested Reference Books: 1. S. Dutta, "Optimization in Chemical Engineering", Cambridge University Press, 2017 2. Mathematical Methods in Chemical & Environmental Engineering: Ajay K. Ray, Thomson Learning, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1		3			2	2		3	
CO2	3	1	1		3			3	1		2	
CO3	3	1	1		3			3	1		2	
CO4	3	1	1		3			3	1		2	
CO5	3	1	1		3			3	1	2	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHE 812</td><td>BOILING HEAT TRANSFER</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites:
Mathematical methods, Transport Phenomena, Heat transfer</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Concept of a vapor bubbles
• CO2: Understanding micro-convection of heat
• CO3: Computing boiling regimes and heat transfer coefficients</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Concept of a vapor bubbles : Boiling; Bubbles; growth mechanisms; modeling issues for pool boiling and flow boiling. [10hrs.]
Module II:
Boiling regimes and heat transfer coefficients
Various boiling regimes; determination of heat transfer coefficients; subcooled boiling; saturated/bulk boiling; [10hrs.]
Module III:
Interfacial Instabilities and Flow Instabilities in Boiling
Types of interfacial instabilities and flow instabilities; their mechanisms; consequences. [10hrs.]
Module IV:
Condensation: Collapse of vapor bubbles; their mechanism; condensation heat transfer coefficients.[10hrs.]
Course Assessment Method: The theory performance of students are evaluated</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Book:</u>
1. John G. Collier, John R. Thome, Convective Boiling and Condensation, Clarendon Press, 1994
2. L S Tong , Y S Tang, Boiling Heat Transfer And Two-Phase Flow, CRC Press, 1997
<u>Suggested Reference Book:</u>
1. R.T. Lahey, Boiling Heat Transfer, ELSEVIER, 1992</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1						1	
CO2	3	2	1	1	1						1	
CO3	3	2	1	1	1						1	

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 813	**CFD APPLICATIONS IN CHEMICAL ENGINEERING**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC 331, CHC 303		CT+MT+EA					

Course Outcomes	• CO1: To learn basics of continuum-based modelling and simulation; Its area of applications and limitations • CO2: To learn different discretization methods of continuum based governing equations • CO3: To learn different steps of CFD simulations • CO4: To learn the use of CFD techniques in realistic problems
Topics Covered	**Module I:** Introduction to Computational Fluid Dynamics, Conservation Equations, Discretization. Different Numerical methods and their comparison; Finite Difference Method, Finite Volume Method, Finite Element Method, etc. Source terms and their linearization, Solution of discretized equations. [12hrs.] **Module II:** Solution of mass and energy equations:Solution of diffusive problems: Steady 1D, Steady 2D and Steady 3D problems. Unsteady 1D, 2D unsteady and 3D unsteady problems, Solution of convective-diffusion problems: Steady and unsteady problems; Different schemes, [18hrs.] **Module III:** Solution of momentum equations: SIMPLE, SIMPLER, SIMPLEC algorithms [10hrs.]
Text Books, and/or reference material	Suggested Text Books: 1.Numerical heat transfer and fluid flow by S.V. Patankar, Hemisphere Publishing Corporation, 1980. 2.Introduction to Computational Fluid Dynamics by Anil W. Date, Cambridge University Press, 1st Edition, 2005. Suggested Reference Books: 1. Computational Fluid Dynamics and Heat Transfer by P. S. Ghosh Dastidar, Cengage India Private Limited

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			3			2			3	
CO2	3	2			3						3	
CO3	3	3			3						3	
CO4	3	3			3			2		2	3	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 814	**NANOTECHNOLOGY**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	• CO1: Acquire the concept of nanotechnology at the basic level to apply for different application. • CO2: Acquire the concept of synthesis and characterization of nanomaterials. • CO3: Acquire the idea how to apply nanotechnology in different fields (catalysis, energy and environment) for better efficiency.
Topics Covered	**Module I:** Introduction to the physics of solid state. Structure and bonding elements of nanoscience & nanotechnology. [8hrs.] **Module II:** Synthesis of nanomaterials: General Top Down and Bottom up approaches. Physical Methods, Chemical Methods & Biological Methods. Mechanical, Structural, Thermal, Electrical & Optical properties. [10hrs.] **Module III:** Characterization techniques of nanomaterials: Spectroscopy, XRD, BET, TGA, SEM and TEM. Some special nanomaterials: Carbon nanotubes, Porous silicon, Zeolites, Aerogels, Core-shell, Hollow and Yolk-shell nanoparticle.[12hrs.] **Module IV:** Application of the nanomaterials in different fields. Nanolithography, Nanocomposites, Nanoparticles as catalyst, Nanoparticles in energy and environment application, Nanoparticles in biomedical application.[12hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. T. Pradeep, Nano: The Essentials, Understanding Nanoscience and Nano Technology, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007. 2. Nanotechnology: Principles & Practices; Sulabh K. Kulkarni, Capital Publishing Company, Kolkata Suggested Reference Books**:** 1. Principles of nanotechnology: N. Phanikumar; Scitech, Kolkata 2. Introduction to nanotechnology: Charles P. Poole & Frank Li Owens, Wiley India (p) Ltd, New Delhi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1	2							
CO2		2										2
CO3			3		2			3				

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN COMPUTER SCIENCE AND ENGINEERING

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in ______ Senate # _______________ # Item no: _______

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Program Name: Bachelor of Technology in Computer Science & Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR COMPUTER SCIENCE & ENGINEERING- B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III								
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4	4
2	CSC301	Discrete Mathematics	3	0	0	3	3
3	CSC302	Digital Logic Design	3	0	0	3	3
4	CSC303	Data Structures and Algorithms	3	1	0	4	4
5	PHC331	Physics of Semiconductor Devices	3	0	0	3	3
6	PHS381	Semiconductor Devices Laboratory	0	0	3	1.5	3
7	CSS351	Digital Logic Design Laboratory	0	0	3	1.5	3
8	CSS352	Data Structures and Algorithms Laboratory	0	0	4	2	4
9	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0	0
		TOTAL	15	2	10	22	27
Semester - IV								
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CSC401	Computer Organization and Architecture	3	1	0	4	4
2	CSC402	Theory of Computation	3	0	0	3	3
3	CSC403	Design and Analysis of Algorithms	3	1	0	4	4
4	CSC404	Object Oriented Programming	2	1	0	3	3
5	CSC405	Signals and Systems	3	0	0	3	3
6	YYO44*	Open Elective - 1	3	0	0	3	3
7	CSS451	Computer Organization Laboratory	0	0	3	1.5	3
8	CSS452	Object Oriented Programming Laboratory	0	0	3	1.5	3
9	CSS453	Signal Processing Laboratory	0	0	3	1.5	3
	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0	0
		TOTAL	17	3	9	24.5	29
Semester - V								
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CSC501	Operating Systems	3	0	0	3	3
2	CSC502	Database Management System	3	1	0	4	4
3	CSC503	Compiler Design	3	0	0	3	3
4	CSC504	Embedded Systems	3	0	0	3	3
5	YYO54*	Open Elective - 2	3	0	0	3	3
6	CSS551	Design and Analysis of Algorithms Laboratory	0	0	3	1.5	3
7	CSS552	Embedded Systems Laboratory	0	0	3	1.5	3
8	CSS553	Operating Systems Laboratory	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0	0
		TOTAL	15	1	9	20.5	25

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3	3
2	CSC601	Software Engineering	3	0	0	3	3
3	CSC602	Data Communication and Computer Networks	3	1	0	4	4
4	CSE610 --	Depth Elective - 1	3	0	0	3	3
5	CSE610 --	Depth Elective - 2	3	0	0	3	3
6	CSS651	Compiler Laboratory	0	0	3	1.5	3
7	CSS652	Data Communication and Computer Networks Laboratory	0	0	3	1.5	3
8	CSS653	Database Management System Laboratory	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0	0
		TOTAL	15	1	9	20.5	25
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3	3
2	CSE710 --	Depth Elective – 3	3	0	0	3	3
3	CSE710 --	Depth Elective - 4	3	0	0	3	3
4	CSE710 --	Depth Elective - 5	3	0	0	3	3
5	YYO74*	Open Elective - 3	3	0	0	3	3
6	CSS751	Software Engineering Laboratory	0	0	3	1.5	3
7	CSS752	Modelling and Simulation Laboratory	0	1	3	2.5	4
8	CSS753	Vocational Training / Summer Internship and Seminar	0	0	2	1	2
9	CSS754	Project - I	0	0	3	1	3
		TOTAL	15	1	11	21	27
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CSE810 --	Depth Elective - 6	3	0	0	3	3
2	YYO84*	Open Elective - 4	3	0	0	3	3
3	YYO85*	Open Elective - 5	3	0	0	3	3
4	CSS851	Project - II	0	0	15	5	15
5	CSS852	Project Seminar	0	0	0	1.5	0
6	CSS853	Viva Voce	0	0	0	1	0
		TOTAL	9	0	15	16.5	24

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45	22	24.5	20.5	20.5	21	16.5	170

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
CSE612	System Software
CSE613	Internet and Web Technologies
CSE614	Advanced Computer Architecture
CSE615	Optimization Techniques
CSE616	Artificial Intelligence
CSE617	Advanced Algorithms
CSE618	Information Coding Theory
CSE619	Computer Graphics
CSE620	Game Theory and its Applications
CSE621	Digital Systems Testing
CSE622	Soft Computing
CSE623	Advanced Database Systems

7th Semester

	DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
CSE710	Machine Learning
CSE711	Graph Theory
CSE712	Electronic Design Automation
CSE713	Natural Language Processing
CSE714	Data Warehousing and Data Mining
CSE715	Digital Image Processing
CSE716	Data Analytics
CSE717	Biometrics
CSE718	Cryptography and Network Security
CSE719	Multimedia Information Systems

CSE720	Cellular Automata and its Application
CSE721	Computational Geometry
CSE722	Complex Network Theory
CSE723	Pattern Recognition
CSE724	Semantic Web Technology
CSE725	Human Computer Interaction
CSE726	Incentive Mechanism in Computer Science

8th Semester

	DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
CSE811	Distributed Systems
CSE812	Computer Vision
CSE813	Optical Networks
CSE814	Internet of Things
CSE815	Cloud Computing
CSE816	Mobile Computing
CSE817	Expert Systems
CSE818	Ethics Society and Computer Science
CSE819	Knowledge Management

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of function, limit, differentiation, and integration.	CT+MT+EA

Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10)

	Sequences and Series: Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems.						

	CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC 01</td><td>Engineering Chemistry</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications
• CO2: To learn fundamentals of polymer chemistry and petroleum engineering.
• CO3: Introduced to basic spectroscopic techniques for structure determination and characterization.
• CO4: To study few inorganic and bioinorganic compounds of industrial importance.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">ORGANIC CHEMISTRY
i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3)
ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3)
iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2)
iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)
v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3)
INORGANIC CHEMISTRY
i. Coordination Chemistry: Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-</td></tr>
</table>

	Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>XEC01</td><td>ENGINEERING MECHANICS</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams.
• CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis.
• CO3: Ability to calculate centroid, moments of inertia for various shapes.
• CO4: Learn momentum and energy principles.
• CO5: Knowledge on virtual Work Principle and its application</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Engineering Mechanics; measurement and SI units. [1]
Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2]
Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4]
Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5]
Simple trusses; analysis of trusses by method of joints and method of sections. [5]
Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4]
Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6]
Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12]
Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition
2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India
3) F P Beer and E R Johnston, Vector Mechanics for Engineers
4) I H Shames, Engineering Mechanics</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.						
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]						
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)						
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.						
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.						
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes

- CO1: To learn basic analytical techniques useful for engg applications.
- CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance.
- CO3: Learn chromatographic separation methods.
- CO4: Applications of spectroscopic measurements.

Topics Covered

i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter.
ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH.
iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry
iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration.
v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc.
vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone.
vii. Synthesis of polymer: polymethylmethacrylate
viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution.
ix. Chromatography: Separation of two amino acids by paper chromatography
x. Determination of saponification value of fat/ vegetable oil

<u>Suggested Text Books:</u>

1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall
2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu
3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra

<u>Suggested Reference Books:</u>

1. Practical Chemistry By R.C. Bhattacharya
2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>WSS51</td><td>WORKSHOP PRACTICE</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Study and practice on machine tools and their operations
• CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
• CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
• CO4: Develop basic electrical engineering knowledge for house wiring practice</td></tr>
<tr><td>Topics Covered</td><td colspan="7">M/c shop & Carpentry shop -- 3X3= 9hrs.
• Introduction on machining process.
• Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
• Introduction to woods- Types, structure, disease and defect of wood.
• Introduction to wood working machines and tools.
• Making of dovetail joint and bridle joint.
Welding Shop & Sheet metal -- 3X3= 9hrs.
• Introduction to welding.Safety and precautions in welding.
• Formation of weld bead by SMAW on mild steel flat.
• Formation of weld bead by oxy-fuel welding on mild steel flat.
• Introduction to sheet Metal works.
• Tools and Machines used in sheet metal works.
• Concept of development, marking out of metal sheets.
• Cutting and joining of metal sheets.
• Safety precautions, General warning needed in the shop floor.
Black smithy & Foundry -- 3X3= 9hrs.
• Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
• Safety and precautions in blacksmithy.
• Making of bars of different cross-sections.
• Making of hexagonal headed bolts.
• Forge welding.
• Introduction to Foundry Technology.
• Preparation of sand mould using Solid/Split Pattern.
Fitting & Electrical shop -- 3X3= 9hrs.
• Introduction to hand metal cutting tools with specifications, nomenclature and their use.
• Marking tools, measuring tools and their use.
• Fitting of joints of mild steel flats.</td></tr>
</table>

	• Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))						
NIL	CT+EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar.						

	• Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET**

	• Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi),

	Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					

Course Outcomes	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.
Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)

	Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
	Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10^{th} ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3^{rd} Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic knowledge of computer.	CT+MT+EA
Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's

	(operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC01</td><td>Basic Electronics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">(10+2) level mathematics and physics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Knowledge of Semiconductor physics and devices.
• CO2: Have an in depth understanding of basic electronic circuit, construction, operation.
• CO3: Ability to make proper designs using these circuit elements for different applications.
• CO4: Learn to analyze the circuits and to find out relation between input and output.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Semiconductors
1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium
1.2. Definitions of insulator, conductor and semiconductor using band diagram
1.3. Crystalline structure of semiconductor
1.3.1. Covalent bond
1.3.2. Generation of holes and electrons
1.3.3. Effect of temperature on semiconductor
1.4 Intrinsic semiconductor
1.5 Doping and Extrinsic semiconductor
1.5.1 n-Type semiconductor and band diagram
1.5.2 p-Type semiconductor and band diagram
1.5.3 Mass-action law of semiconductor
1.6. Conductivity of semiconductor (including mathematical expression)
1.7 Carrier transport phenomenon. (03 hrs.)
2. Diodes
2.1. Construction</td></tr>
</table>

	2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741,

	9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="10">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.
• CO4: introduce the basic concept of single-phase transformer.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Overview of Electrical power generation systems (2)
Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4)
Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4)
Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8)
Transients with D.C. excitation for R-L and R-C circuits. (3)
Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10)
Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6)</td></tr>
<tr><td>Textbooks/Reference material</td><td colspan="7">Textbooks:
1. Electrical & Electronic Technology by Hughes, Pearson Education India
Reference Books:
1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd
2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis,

	TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition,

	Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)						

Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS 51</td><td>Basic electronics Lab</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire idea about basic electronic components, identification, and behavior.
• CO2: To determine IV characteristics of these Circuit elements for different applications.
• CO3: Learn to analyze the circuits and observe and relate input and output signals.</td></tr>
<tr><td>Labs Conducted.</td><td colspan="7">1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments.
2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it.
3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms.
4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.
5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs
6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs
7. Transistor as a Switch: study and perform transistor as a switch through NOT gate
8. Zenner diode as voltage regulator
9. To study clipping and Clamping circuits
10. To study different biasing cirtis.
11. Study of CE amplifier and observe its frequency response.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al.
<u>Reference Books</u>:
1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill
2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: understand the principle of superposition. • CO2: understand the principle of maximum power transfer • CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: understand the calibration of energy meter. • CO5: understand open circuit and short circuit test of single-phase transformer. • CO6: analyze RLC series and parallel circuits • CO7: understand three phase connections. • C08: understand determination of B-H curve						
Topics Covered	**List of Experiments:** 1. To verify Superposition and Thevenin's Theorem. 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit 9. Determination of B-H Curve for magnetic material						
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru (Author), J M Chuma (Author), H U Ezea (Author) 2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>XXS-52</td><td>Co-curricular Activities</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Pre-requisites</td><td colspan="7">Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)</td></tr>
<tr><td>NIL</td><td colspan="7">CE + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Social Interaction: Through the medium of sports
CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them
CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.
CO4: Personality development through community engagement
CO5: Exposure to social service</td></tr>
<tr><td>Topics Covered</td><td colspan="7">YOGA
Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana.
Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra.
Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana.
Meditation- ‘Om’meditation, Kundalini or Chakra Meditation, Mantrameditation.
Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose).
Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari.
Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha.
Kriya- Kapalabhati, Trataka, Nauli.
ATHLETICS
Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing
Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through.
Field events marking.
General Rules of Track & Field Events.
BASKETBALL
Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw.
Rebounding- Defensive rebound, Offensive rebound.
Individual Defensive- Guarding the man without ball and with ball.</td></tr>
</table>

	• Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service.

	• Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

THIRD SEMESTER

MAC331 MATHEMATICS-III 3-1-0 4 Credit 4 Hrs

Department of Mathematics								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	MATHEMATICS-III	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic knowledge of topics included in MAC01 & MAC02		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. • CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. • CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. • CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.						
Topics Covered	**<u>Partial Differential Equations (PDE):</u>** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **<u>Numerical Methods:</u>** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **<u>Complex Analysis:</u>** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **<u>Optimization:</u>** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]							

Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K.Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 301 Discrete Mathematics 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 301	Discrete Mathematics	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Remember the basic terms, definitions and concepts of mathematics. • CO2: Students will be able to understand the key concepts of discrete mathematics such as functional mapping, mathematical logic, counting principles, generating functions, algebraic structures and graph theory. • CO3: Students will be able to apply the learned concepts to solve various problems. • CO4: Students will be able to differentiate or relate the various ideas with respect to problems. • CO5:Students will be able to judge the formulas and ideas to be applicable to a problem.						
Topics Covered	**Set Theory:** Definition of Sets, Venn Diagrams, complements, cartesian products, power sets, counting principle, cardinality and countability (Countable and Uncountable sets), proofs of some general identities on sets, pigeonhole principle. (3L)						

	Relation: Definition, types of relation (reflexive, symmetric, transitive, antisymmetric, Equivalence, partial ordering relations), composition of relations, domain and range of a relation, pictorial representation of relation, properties of relation, Partial Order, Lattice, Hasse Diagram. (6L) **Function:** Definition and types of function, composition of functions, recursively defined functions, Surjection, Injection, Bijection, Composition of Function, Asymptotic notations: big-Oh, Theta, big-Omega. (4L) **Propositional logic:** Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification. Notion of proof: proof by implication, converse, inverse, contrapositive, negation, and contradiction, direct proof, proof by using truth table, Proof by Well ordering principle. (6L) **Combinatorics:** Mathematical induction, recursive mathematical definitions, basics of counting, permutations, combinations, inclusion-exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relation using G.F, solution of combinatorial problem using G.F.). (8L) **Algebraic Structure:** Binary composition and its properties definition of algebraic structure; Semi group, Monoid, Groups, Abelian Group, properties of groups, Permutation Groups, Sub Group, Cyclic Group. (6L) **Graphs:** Graph terminology, types of graph, connected graphs, components of graph, Euler graph, Hamiltonian path and circuits, Degree Sequence, Radius, Diameter, Center of a graph, Graph coloring, Chromatic number. Planarity of a graph: K(3,3) and K(5). Clique, Independent set, bipartite graph, Tree: Definition, types of tree (rooted, binary), properties of trees. (9L)
Text Books, and/or reference material	**Text Books:** 1. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw Hill. 2. Norman L. Biggs, Discrete Mathematics, Oxford. 3. Douglas B. West, Introduction to Graph Theory, Prentice Hall, India. **Reference Books:** 1. Ronald L. Graham, Donald E. Knuth and O. Patashnik, Concrete Mathematics, Pearson Education.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	-	1	2
CO2	3	3	2	2	2	-	-	-	-	-	2	2
CO3	3	3	2	2	2	-	-	-	-	-	2	2
CO4	3	3	2	2	2	-	-	-	-	-	2	2
CO5	3	3	2	2	2	-	-	-	-	-	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC302 Digital Logic Design 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 302	Digital Logic Design	PCR	3	0	0	3	3
Pre-requisites:		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	At the completion of this course students will be able to: • CO1: Realize the various logic gates and laws of Boolean algebra. Analyze different types of digital electronic circuit using various mapping and logical tools. • CO2: Design and analyses the various combinational circuits. • CO3: Design and analyze the various sequential circuits. • CO4: Design and analyze combinational and sequential logic circuits through HDL models. • CO5: Synthesis the various logic using ASM charts.						
Topics Covered	**UNIT-I**: **Switching Circuits,** Various number system and their conversions: Arithmetic of these number systems, Complements, Data Representation: Binary numbers, binary codes, fixed point representation, floating point representation, Code and their conversions, Addition and Subtraction on Codes, Error Detection codes (Hamming code etc), representation of signed binary number in Fixed and Floating Points. (5L) **UNIT-II**: **Boolean algebra**, logic gates, and switching functions, truth tables and switching expressions, minimization of completely and incompletely specified switching functions, Karnaugh map and Quine-McCluskey method, multiple output minimization, representation and manipulation of functions using BDDs, two-level and multi-level logic circuit synthesis. (10L) **UNIT-III**: **Combinational logic circuits**: Realization of Boolean functions using AND/NOR Gates, Decoders, multiplexers. Logic design using ROMs, PLAs and FPGAs. Case Studies.						

	(8L) **UNIT-IV**: **Sequential circuits:** Clocks, flip-flops, latches, counters and shift registers, finite-state machine model, synthesis of synchronous sequential circuits, minimization and state assignment, asynchronous sequential circuit synthesis. (12L) **UNIT-V**: FSM and **ASM charts**: Representation of sequential circuits using FSM and ASM charts, synthesis of output and next state functions, data path control path partition-based Design. (7L)
Text Books, and/or reference material	**Text Books:** 1. Digital Logic Design, M. Morris Mano, Michael D Cilleti, PHI. **Reference Books:** 1. Digital Principles & Application, 5th Edition, Leach & Malvino, McGraw Hill Company. 2. Modern Digital Electronics, 2nd Edition, R.P. Jain. Tata Mc Graw Hill Company Limited.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	-	-	-	-	-	1	2
CO2	3	2	2	3	1	-	-	-	-	-	2	2
CO3	3	2	2	3	1	-	-	-	-	-	2	2
CO4	3	2	2	3	2	-	-	-	1	-	2	2
CO5	3	2	2	3	3	-	-	-	1	-	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC303 Data Structures and Algorithms 3-1-0 4 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 303	Data Structures and Algorithms	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC-01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding the fundamental concepts of data, data types and abstract data types. • CO2: Implementation of different abstract data types using different data structures. • CO3: Apply different types of data structures to implement different						

	application problems. ● CO4: Different searching and sorting techniques. ● CO5: Analysis of the suitability/compatibility of different data structures based on the types of applications. ● CO6: Design and development of algorithms for real-life applications.
Topics Covered	Introduction to problem solving through computer, Design of algorithm to solve a problem, Concept of static and dynamic memory allocation, Algorithms and data structures, Concept of Abstract Data Type (ADT) with examples. (3L) Efficiency of an algorithm, Asymptotic notations, Time and space complexities, Analysis of algorithms, Comparing asymptotic running times, Impact of data structure on the performance of an algorithm. (4L) Array, Single and multi-dimensional array, Memory representation (row major and column major) of array, Insertion, and deletions in array, Advantages and disadvantages of array. (3L) Linked list as an ADT, Memory allocation and deallocation for a linked list, Linked list versus array, Types of linked lists: singly linked list, doubly linked list and circular linked list, Operations on linked list: creation, display, insertion and deletion (in different positions), summation, average, maximum, minimum etc. Application of linked list: representations and operations on polynomials, sparse matrices. (7L) Stack as an ADT, Main operations (push and pop), auxiliary operations and axioms, Array implementation of stack, Limitation of array implementation, Linked list implementation of stack, Applications of stack: Recursion, Function call, Evaluation of postfix expression using stack, Conversion of infix to postfix using stack. (6L) Queue as an ADT, Main operations (enqueue and dequeue), Auxiliary operations and axioms, Array implementation of queue, Limitation of array implementation and Circular queue, Linked list implementation of queue, Double ended queue (dequeue) Priority queue and its applications. (5L) Binary Tree, Definition and properties, Representation of binary tree in memory: linked representation, array representation, Binary tree traversal, Preorder, Inorder and Postorder, Expression tree, Heap and its applications. (5L) Search trees: Binary search tree, Balanced binary search tree, AVL tree, Red Black tree, M-way tree, M-way search tree, B tree, B+ Tree. (7L)

	Searching: Linear search and binary search. (3L) Sorting: Bubble, selection, insertion, Quick sort, Merge sort, Heap sort, Radix sort. (7L) Graphs: Mathematical Properties, Degree, Connectedness, Representation using matrix, Adjacency list, Directed Graphs, Directed Acyclic Graph. (2L) Hashing: Hash functions. Collision, Collision resolution techniques: linear probing, quadratic probing, double hashing, chaining, Rehashing. (4L)
Text Books, and/or reference material	**Text Books:** 1. R. F. Gilberg and B. A. Forouzan, "Data Structures: A pseudocode approach with C", 2nd Edition, CENGAGE Learning. 2. A. V. Aho, J. D. Ullman and J. E. Hopcroft, “Data Structures and Algorithms”, Addition Wesley. 3. Lipschutz, “Data Structures (Schaum’s Outline Series)”, Tata Mcgraw Hill. 4. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). **Reference Books:** 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 3. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	-	-	-	-	-	-	-	-	-
CO2	2	-	3	1	-	-	-	-	-	-	-	-
CO3	3	-	3	1	-	-	-	-	-	-	-	-
CO4	3	2	3	1	-	-	-	-	-	-	-	-
CO5	3	3	3	2	-	-	-	-	-	-	-	-
CO6	3	3	3	2	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

PHC331 PHYSICS OF SEMICONDUCTOR DEVICE 3-0-0 3 Credits 3 Hrs

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PCR)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHC331</td><td>Physics of Semiconductor Devices</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">PHC 01 in 1st year.</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of the course, a student will be able to:
CO1.Describe the different electronic properties of semiconductor materials.
CO2. Understand the working principal of electronic devises (PN Diode, Photodetector, Solar cell, Light-Emitting Diodes, Laser Diodes, JFET, MOSFET, Tunnel Diode, Gunn Diode, IMPATT Diode, TRAPATT Diode and semiconductor memory).
CO3. Apply the knowledge of memory expansion to design required expanded memory for specific application.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of Semiconductor & Semiconductor Devices Fabrication: Introduction to crystal growth, Intrinsic and extrinsic semiconductors, Fermi level, Conductivity, Mobility and its temperature dependence, Energy bands of semiconductors, Direct and indirect semiconductor, Variation of energy band with alloy composition, III-V and II-VI alloy semiconductor, Homo and hetero-structure semiconductor, Effective masses of carriers in semiconductor, Fermi-Dirac distribution function, Density of states, Carrier concentrations at equilibrium, Calculation of number density of carriers and their temperature dependence, Effects of temperature on carrier concentrations, High field effects, Hall effect, Lithography, Optical lithography and Electron beam lithography. [14]

Junction-Diode & Optoelectronic Devices: P-N junction, Contact potential, Band diagram, Degenerate semiconductors, Photodetector, Solar cell, Light-Emitting Diodes, Internal and external quantum efficiency etc., Semiconductor Lasers, Population inversion at a junction, Emission spectra for P-N junction Lasers. [3]

Negative Conductance Microwave Devices: Materials for negative conductance devices, The Gunn effect and related devices, The transferred electron mechanism, Transit time devices, The IMPATT Diode, the TRAPATT Diode,Tunnel Diode. [10]

JFET and MOSFET: Junction Field Effect Transistors (JFET), Operation, I-V Characteristics etc., MOS structure, Different MOS structures, Operation of MOS at high and low frequency, Accumulation, Inversion, strong inversion regions, Metal-Oxide Semiconductor Field Effect Transistors (MOSFET), MOSFET as a Capacitor,</td></tr>
</table>

	MOSFET as a resistor and related circuits. [9] **Semiconductor Memory Device:** Semiconductor memory organization, Random Access Memory (RAM) (static and dynamic), CMOS memory circuits, Charge Coupled Devices (CCD). [6]
Text Books, and/or reference material	**Text Books** 1. Physics of Semiconductor Devices, S M SZE. 2. Solid State Electronic Devices, Ben G Streetman & Banerjee 3. Microwave Solid-State Devices, S Y Liao **References:** 1. Semiconductor Physics and Devices, Donald A. Neamen. 2. Microwave Engineering, David M.Pozar. 3. Integrated Electronics, Millman-Halkias.

Mapping of CO (Course outcome) and PO (Programme Outcome)

POs COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	2	1	-	1	1	1	-	-	-	2	-	-	1
CO2	3	2	1	1	1	1	1	1	1	1	-	2	1	1	1
CO3	3	3	2	1	1	1	1	1	1	1	1	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

PHS381 SEMICONDUCTOR DEVICES LABORATORY 0-0-3 1.5 Credits 3 Hrs

Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS381	Semiconductor Devices Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
PHS 51 in 1st year.		CE+EA					
Course Outcomes	At the end of the course, a student will be able to: • CO1. Calculate different characteristic parameter of semiconductor materials. • CO2. Measure and understand different characteristic of semiconductor devices. • CO3. Draw the current-voltage characteristics of solar cell for calculation of conversion efficiency.						
Topics Covered	**List of Experiments:** 1. To determine the energy bandgap of a semiconductor. 2. Measurement of resistivity of semiconductors by four-probe method at different temperatures. 3. Determination of Hall coefficient of a given semiconductor and its temperature						

	dependence. 4. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnet. 5. Determination of Stefan's constant. 6. Study of p-n junction diode characteristics. 7. Study of Zener diode characteristics and voltage regulator. 8. Determination of photo conversion efficiency of a Solar cell.
Text Books, and/or reference material	**Text Books** 1. An advanced course in practical physics, Chattapadhyay and Rakshit. 2. Advanced Practical Physics, B. Ghosh and K. G. Mazumdar

Mapping of CO (Course outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	-	-	-	-	1	1	1	-	2	1	-	1
CO2	3	2	1	-	-	-	-	1	1	1	-	2	1	-	1
CO3	3	2	1	-	1	1	1	1	1	1	-	2	2	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS351 Digital Logic Design Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS351	Digital Logic Design Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
NIL		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	● CO1: Understand basic gate operations. ● CO2: Realize the boolean function using basic gates in both SOP/POS form. ● CO3: Realize different combinational circuits with basic gates. ● CO4: Understand the basic structure of different digital components- multiplexer, decoder, encoder etc. ● CO5: Verification of state table of different flip flop using NAND/NOR gate.						
Topics Covered	1. Familiarization with IC, study of the data sheet, VCC, Ground. Verification of the truth tables. 2. Implementation of a given Boolean function using logic gates in both SOP and POS forms. Verify the Universal logic gate (NAND, NOR). 3. Verify DE Morgan's law.						

	4. Implement NAND based logic circuit for any Boolean expression. Verify that a Boolean expression, e.g. F= AB + A'C'. is functionally complete. 5. Implement a Full adder using Half Adder. Implement the combinational circuit to realize both Adder and Subtractor together. 6. Implementation and verification of Decoder, Multiplexer, Encoder and Priority Encoder etc. 7. Implement and verify Ripple Carry Adder, Carry Look Ahead Adder and BCD Adder. 8. Verification of state tables of RS, JK, T and D flip-flops using NAND & NOR gates. 9. Implement and verify the 4-bit counter
Text Books, and/or reference material	**Text Books:** 1. Digital Logic Design, M. Morris Mano, Michael D Cilleti, PHI. **Others:** 1. Laboratory Manual.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	2	2	-	-	-	1	-	-	-
CO2	3	2	1	2	2	-	-	-	1	-	-	-
CO3	3	2	1	2	2	-	-	-	1	-	-	-
CO4	3	2	1	2	2	-	-	-	1	-	-	-
CO5	3	2	1	2	2	-	-	-	1	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS352 Data Structures and Algorithms Laboratory 0-0-4 2 Credits 4 Hours

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS352</td><td>Data Structures and Algorithms Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
</table>

Pre-requisites	Course Assessment methods (Continuous Assessment (CT) and End assessment (EA))
CSC-01 (Introduction to Computing), CSS-51 (Computing Laboratory)	CT+EA [CT: 60%, EA (Programming assignment + Viva Voce): 40%]

Course Outcomes	• CO1: Implement linear and non-linear data structures using linked list. • CO2: Implement stack, queue, tree using array and linked list for problem solving. • CO3: Implement operations and techniques like insertion and deletion, traversal, searching and sorting on various data structures. • CO4: Analyze the time and space complexity of the algorithms.

	• CO5: Choose appropriate data structures for representation and manipulation of the data for the given problems.
Topics Covered	1. Insertion and deletion in arrays using dynamic memory allocation. 2. Linear search, Binary search (recursive, non-recursive). 3. Memory allocation and deallocation for linked list. 4. Operations on linked list: creation, display, insertion and deletion (in different positions), summation, average, maximum, minimum etc. 5. Array implementation of stack and queue. 6. Linked implementation of stack and queue. 7. Evaluation of postfix expression using stack. 8. Conversion of infix expression to its postfix version using stack. 9. Linked implementation of binary tree and preorder, inorder and postorder traversal on binary tree. 10. Implementation of binary search tree and operations on it (searching, insertion, deletion). 11. Implementation of height-balanced binary search tree (AVL tree). 12. Implementation of 2-3 tree. 13. Implementation of Chaining. 14. Implementation of sorting algorithms: Selection sort, insertion sort, bubble sort, quick sort, heap sort, merge sort, radix sort. 15. Implementation of few basic graph operations (such as breadth first and depth first traversal, finding minimum spanning tree, shortest path) on graph.
Text Books, and/or reference material	**Text Books:** 1. S. Lipschutz, “Data Structures (Schaum’s Outline Series)”, McGraw Hill Education; First edition (2017). 2. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). 3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Edu India Private Limited, Seventh edition (2017). **Reference Books:** 1. B. S. Gottfried, "Programming with C", McGraw Hill Education, Fourth ed (2018).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	2	-	-	-	-	-	-	-	-	-
CO2	3	2	2	1	-	-	-	-	-	-	-	-
CO3	3	2	2	1	2	-	-	-	-	-	-	-
CO4	3	2	2	1	2	-	-	-	-	-	-	-
CO5	3	3	3	2	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

CSC 401 Computer Organization and Architecture 3-1-0 4 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 401	Computer Organization and Architecture	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Logic Design (CSC302)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Analyze the various parts of a modern computer functional units, bus structure, addressing modes and Computer arithmetic. • CO2: Identify the process involved in executing an instruction and fetching the word from memory. • CO3: Design the hardwired and micro-programmed control units and implementation of interrupts. • CO4: Understand the memory hierarchy and design a memory system. • CO5: Understand Pipelined execution and instruction scheduling.						
Topics Covered	**UNIT-I**: Introduction: Evolution of computers, Basic Structure of Computers: Basic Operational Concepts, GPR based and stack based organisation. Bus Structures, Performance Measurement: Processor Clock, Basic Performance Equation, Clock Rate, Machine Instructions and Programs: Memory Location and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes, Assembly Language, Basic Input and Output Operations, Encoding of Machine Instructions (Huffman encoding etc). (12L) **UNIT-II**: Fundamental concepts of the processing Unit: Fetching and Storing words, Register Transfer, Execution of instruction, Arithmetic Operations: Addition and Subtraction of Signed Numbers, Design of Fast Adders, Combinational and Sequential ALU, ALU expansion strategies, Design of Multipliers and Dividers, Wallace tree and Booth's Multipliers, Floating Point Numbers (IEEE754), Floating Point Operations, Multiplication of Positive Numbers, Signed Operand Multiplication (Booth's Multiplication etc.), Fast Multiplication, Integer Division. (10L) **UNIT-III**: Computer Organization and Design (Datapath and control path): Instruction codes, computer registers, computer instructions, timing & control, instruction cycle, memory reference instructions, Hard-wired Control, Micro programmed Control: Micro instruction, Microprogram sequencing, Input/output Organization: Accessing I/O Devices, Interrupts – Interrupt Hardware, Enabling and Disabling Interrupts, Handling Multiple Devices, Controlling Device Requests, Exceptions, Direct Memory Access, Buses, Interface Circuits, Standard I/O Interfaces – PCI Bus, SCSI Bus, Bus Arbitration schemes, USB. (Brief overview of 8085/8086 microprocessor). (12L)						

	UNIT-IV: Memory System: Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, Cache Memories – Mapping Functions, Replacement Algorithms, page mode access, interleaved access. Performance Considerations, Virtual Memories, Secondary Storage. (12L) **UNIT-V**: Basic concepts of pipelining, the instruction pipeline – pipeline hazards – instruction level parallelism – reduced instruction set –Computer principles – RISC versus CISC. Introduction to GPP, ASIP and ASIC etc. (10L)
Text Books, and/or reference material	**Text Books:** 1. David A Patterson, John L Hennessy, "Computer Organization and Design", (The Hardware/Software Interface) Morgan Kaufmann. 2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, 5th Edition, Tata McGraw Hill. **Reference Books:** 1. **William Stallings, "Computer Organization and Architecture".** 2. Nicholas P Carter, "Computer Architecture & Organisation".

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	1	-	-	-	-	-	1	2
CO2	3	1	2	2	1	-	-	-	-	-	2	2
CO3	3	1	2	2	1	-	-	-	-	-	2	2
CO4	3	2	2	3	2	-	-	-	1	-	2	2
CO5	3	2	2	3	2	-	-	-	1	-	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 402 Theory of Computation 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC402	Theory of Computation	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Discrete Mathematics (CSC 301)		CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]					
Course Outcomes	• CO1: Explain the concept of regular languages through regular expressions and finite automata. • CO2: Describe context-free languages and context free grammars. • CO3: Design grammars and automata for various languages. • CO4: Examine the power of Turing machines and design TM for simple problems. • CO5: Analyze the concept of undecidability in the context of Turing						

	machine design.
Topics Covered	1. Regular sets and Regular Expression, Non-deterministic and deterministic finite automata and their equivalence, Minimization of deterministic finite automata, Regular expressions to Finite Automata. (10L) 2. Finite Automata with outputs. (2L) 3. Properties of Regular Sets: Pumping Lemma, Closure Properties, Decision algorithms. (5L) 4. Context Free Grammars. Derivations. Ambiguity in grammars. (3L) 5. Chomsky hierarchy of languages and grammars. Regular grammars. (3L) 6. Normal Forms for Context free grammars. CNF and GNF. Closure properties of context free languages, Pumping lemma for context free languages. Decision Properties. (10L) 7. Pushdown automata. (3L) 8. Turing machines. Unrestricted Grammars. Properties of recursive and r.e. languages, Undecidability. (6L)
Text Books, and/or reference material	**Text Books:** 1. Introduction to Automata Theory, Languages and Computation by J.E.Hopcroft, Rajiv Motwani and J.M.Ullman. Pearson Education. 2. Introduction to Languages and Theory of Computation By John C. Martin McGraw Hill Education **Reference Books:** 1. Elements of the Theory of Computation By Harry R. Lewis and Christos H. Papadimitriou Prentice Hall of India. 2. Theory of Automata and Formal Languages By Anand Sharma University Science Press

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	-
CO2	3	3	3	3	2	-	-	-	-	-	-	-
CO3	3	3	3	3	2	-	-	-	-	-	-	-
CO4	3	3	2	3	1	-	-	-	-	-	-	-
CO5	3	3	1	3	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 403 Design and Analysis of Algorithms 3-1-0 4 Credits 4 Hours

<table>
<tr><th colspan="8">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 403</td><td>Design and Analysis of Algorithms</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Discrete Mathematics (CSC 301), Data Structure and algorithm (CSC 303)</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to understand many important concepts such as asymptotic analysis, dynamic programming, recurrences etc.
CO2: Students will be able to describe the key ideas of different algorithm design paradigms.
CO3: Can apply different algorithmic ideas efficiently to solve new problems.
CO4: Students can analyze and understand the time complexity of the algorithms, and its correctness.
CO5: Can evaluate the hardness of an algorithm if required.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction and basic concepts: Algorithm, Asymptotic notations (big-Oh, big Omega, Theta, small-oh) and their significance, introduction to RAM model of computation, complexity (Time Complexity, Space Complexity) analysis of algorithms, worst case and average case. Solving Recurrences – Substitution method, Recurrence tree method and Master Method, Finding maximum and minimum of n numbers, Finding the second largest of n numbers and exact number of comparisons.
Lower bound: Lower bound for a problem. Computing the lower bound for sorting (comparison based sorting) and computing the lower bound for computing convex hull using the lower bound for sorting problem. (2L)
Amortized complexity analysis: aggregate analysis, accounting method and potential method. Examples: storage allocation problem, binary counting problem and heap sort. (4L)
Using Induction to Design algorithm: The celebrity problem, Majority Finding problem (2L)
Divide and conquer Problem: Multiplication of two n-bit integers, Strassen’s Matrix Multiplication problem, Closest pair of points, linear time median finding algorithm, Convex hull and its computation. (6L)
The Greedy Algorithm: Greedy algorithms and their correctness proof: Interval scheduling problem, Interval partitioning problem, Minimizing the Lateness of Intervals problem, Fractional Knapsack Problem. (5L)
Dynamic Programming: Longest Common Subsequence, Matrix Chain Multiplication, 0-1 Knapsack Problem, longest common subsequence problem. (6L)</td></tr>
</table>

	Backtracking Method, Branch and Bound Method. (2L) **Graph Algorithms:** Depth First Search, Breadth First Search, Dijkstra's Single Source Shortest Path algorithm; All pair shortest path algorithm, Minimum Spanning Tree (Prim's and Kruskal's algorithm). (7L) **Randomized Algorithm**: Las Vegas and Monte Carlo; Randomized Quick Sort algorithm and Min Cut problem. (3L) **Reducibility between problems and NP-completeness:** Different class of Problems (P, NP, NP-Hard, NP-Complete), Discussion of different NP-complete problems like satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, set cover, dominating set problem. (6L) **Approximation Algorithm:** Approximation ratio for maximization problem and minimization problem, Constant ratio approximation algorithms for metric travelling salesperson problem (TSP) and vertex cover problem, log n ratio approximation algorithm for Set Cover problem. (6L)
Text Books, and/or reference material	**Text Books:** 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, by Prentice Hall India. 2. J. Kleinberg and Eva Tardo, Algorithm Design by Pearson Education (Indian edition). 3. S. Dasgupta, C. Papadimitriou and U. Vazirani, Algorithms, by Tata McGraw-Hill. **Reference Books:** 1. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Wiley, 2006. 2. Algorithms: Design Techniques and Analysis Volume 7 of Lecture notes series on computing, World Scientific, 1999. **Others:** Tim Roughgarden's video lectures and notes of CS161 and *CS261; NPTEL's lectures on Design and Analysis of Algorithms; NMEICT video on Design of Algorithms (http://www.nmeict.iitkgp.ac.in/Home/videoLink/10/3gp).*

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	3
CO2	3	3	3	3	2	-	-	-	-	-	-	2
CO3	3	3	3	3	3	1	1	1	1	1	1	3
CO4	3	3	3	3	2	-	-	-	-	-	-	3
CO5	2	3	2	3	2	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 404 Object Oriented Programming 2-1-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 404	Object Oriented	PCR	2	1	0	3	3

	Programming						

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	• CO1: Understanding of Object Oriented Design Approach and its real world applications • CO2: Analyzing problems in terms of object oriented methodologies. • CO3: Implement programs using concepts of classes and objects. • CO4: Specify the forms of inheritance and use them in problem solving. • CO5: Learn and implement different forms of polymorphism. • CO6: Developing skills to write generic codes
Topics Covered	**Course Introduction-** Concepts of Object Oriented Programming, Procedural approach, Limitation of Procedural Language, Object concept. (2L) **Object Oriented Terminologies**- Class concept, ADT, encapsulation, Cardinality, Data hiding, Inheritance, Polymorphism, Advantages of OOPs, Advantages of OOPs, difference between Procedural and Object Oriented Language, Evolution of C++. (4L) **Basic Input/Output in C++ -** The 1st C++ Program (temperature conversion), compilation, Input stream and output stream, Advantages of cin a cout over pritnf and scanf. (3L) **Basic C++ features -** Literals, Constants, Manipulators, Assertions, Enumerated Data Types, Scope resolution operator. (4L) **Pointers & References in C++**- Basic operations on pointers, Array of pointers, pointer to an array, self referential structures, References in C++ , use of references. (4L) **Dynamic memory allocation/deallocation**- Use of new and delete operator, multi-dimensional array allocation, Examples. (4L) **Constructor and Destructor**, Various examples of constructors, Constructor Salient Features, Destructors,, Examples. (2L) **Functions in C++; Overloading**- function call, Macros, and it's limitations, Inline function, Function Overloading, Constructor Overloading, Examples, Function with Default arguments, Various Examples of Default arguments. (5L) **Writing C++ Classes-** Class, C++ class vs Structure, This pointer, Memory Layout of C++ program, Static member of class. Static Member Functions, Static Object, Examples. (4L) **C++ Constants Revisited** - Storage Allocation, Constants and References, Constant member data and Functions, Constants Objects, Examples. (2L) **Friend Function & Operator Overloading -** Friend Functions, Use of friend

	functions, friends as bridges, Various examples, Operator Overloading, examples, advantages of friend functions during overloading. (4L) **Templates in C++**, Generic function and classes, examples, syntax of a template, Template class (4L) **Inheritance in C++**, Derive class, Parameterized constructor in derive class, Protector Specifier, Examples of different types of inheritance, Virtual Base Class, Up casting. Polymorphism and virtual function, Function call finding, Virtual Functions, Examples. Lecture (38): V Table and V pointer, Pure Virtual Function, Examples. Lecture (39-40): Exception Handling in C++ Lecture (41): Unformatted Input/ Output operations, Formatted I/O functions, File handling. 2-3 Lectures are planned for doubt clearance.
Text Books, and/or reference material	**Text Books:** 1. Adam Drosdek, "DATA STRUCTURES AND ALGORITHMS IN C++" , Brooks/Cole Thomson Learning. 2. Bjarne Stroustrup "The C++ Programming Language", Pearson Education. **3. E. Balaguruswamy, "Object Oriented Programming with C++", Tata McGraw Hill.** **Reference Books:** 1. Bruce Eckel, "Thinking in C++", Prentice Hall. 2. S. B. Lippman, J. Lajoie, B. E. Moo, "C++ Primer", Addison-Wesley Professional **3. Bjarne Stroustrup, "Programming: Principles and Practice Using C++", Addison-Wesley Professional.** 4. Effective C++: 50 Specific Ways to Improve Your Programs and Design by Scott Meyers, 1997. 5. More Effective C++ by Scott Meyers, 2002. **Others**: NPTEL course link by Prof. Partha Pratim Das - https://onlinecourses-archive.nptel.ac.in/noc19_cs10/preview

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	1	3	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	1
CO5	1	2	2	3	3	1	-	-	-	1	3	1
CO6	-	-	3	-	3	3	2	-	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 405 Signals and Systems 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 405</td><td>Signals and Systems</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Calculus, Linear algebra</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">The students, after successfully completing the course, will be able to:
• CO1: Understand the definitions, classifications, properties and applications of signals and systems.
• CO2: Apply Laplace transform, Fourier transform, Z-transform and other mathematical operations for the purpose of analyzing signals and systems.
• CO3: Design and analysis of continuous and discrete time systems.
• CO4: Compare continuous time and discrete time systems in real life applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Signals and systems, introduction to signals, classification of signals; mathematical operations of signals, some standard signals, generating signals using standard signals.
(6L)

Introduction to systems, classification of systems, Linear Time Invariant (LTI) Systems (continuous-time and discrete-time systems), properties of LTI systems, impulse response, convolution, causality, stability;
(6L)
Impulse response of discrete-time LTI systems, discrete time convolution, difference equations and analysis, developing equivalent discrete-time system from a given continuous-time system and analysis of their stability;
(4L)

Laplace Transform, Properties of Laplace Transform, Inverse Laplace Transform;
(4L)

Applications of Laplace Transforms to design and analyse continuous-time systems, transfer function of continuous-time systems, poles and zeros, stability analysis; (4L)

Introduction to Z-Transform, Properties of z-Transform, Region of Convergence, Inverse z-Transform;
(3L)

Applications of Z-Transforms to design and analyse Discrete Time Systems
(3L)</td></tr>
</table>

	Introduction to Fourier analysis, Fourier series for periodic signals, discrete spectrum of periodic signals; (2L) Introduction to Fourier transform, properties of Fourier transform, energy and power spectral density, frequency response of continuous-time systems, some problem examples; (4L) Fourier analysis of Discrete Signals, Discrete Time Fourier Transform (DTFT), Properties of DTFT, Examples of DTFT, DFT. (4L) Concept of state, state space analysis, state space representation of continuous time systems (2L)
Text Books, and/or reference material	**Text Books:** 1. Signals and Systems, 2nd ed., Simon Heykin and Barry Van Veen, John Wiley & Sons. 2. Signals and Systems, Oppenheim and Willsky, Prentice Hall Signal Processing Series. **Reference Books:** 1. Signal Processing and linear systems, B. P. Lathi, Oxford University Press. 2. Theory and Problems of Signals and Systems, Hsu, Schaum's Outline Series.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	-	-	-	-	-	-	1
CO2	2	3	3	3	-	-	-	-	-	-	-	2
CO3	2	3	3	3	-	-	-	-	-	-	-	3
CO4	2	2	2	2	-	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 451 Computer Organization Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 451	Computer Organization Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Digital Logic Design (CSC302), Digital Logic Design laboratory (CSS351)		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course	• CO1: Understand the basic structure of digital computer.						

Outcomes	• CO2: Understand the synchronous / asynchronous logic. • CO3: Perform different operations with flip-flop. • CO4: Understand arithmetic and control unit operation. • CO5: Understand the basic concepts of Memory.
Topics Covered	1. Introduction to Verilog HDL and Implementation of basic logic gates using Verilog. 2. Familiarization of Assembly language programming. 3. Implementation of combinational circuits using Verilog. 4. Implementation of sequential circuits using Verilog. 5. Implementation of Booth's Multiplier circuit. 6. Synthesis of simple data path and Controllers, Processor Design 7. Implementation of Random Access Memory (RAM) to perform both R/W operation. 8. Mini project.
Text Books, and/or reference material	**Text Books:** 1. David A Patterson, John L Hennessy, "Computer Organization and Design", (The Hardware/Software Interface) Morgan Kaufmann. 2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, 5th Edition, Tata McGraw Hill. **Reference Books:** **1. William Stallings, "Computer Organization and Architecture".** **2. Nicholas P. Carter, "Computer Architecture & Organisation".** **Others: Laboratory Manual**

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	2	2	-	-	-	1	-	-	-
CO2	3	2	1	2	2	-	-	-	1	-	-	-
CO3	3	2	1	2	2	-	-	-	1	-	-	-
CO4	3	2	1	2	2	-	-	-	2	-	-	-
CO5	3	2	1	2	2	-	-	-	1	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 452 Object Oriented Programming Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS452	Object Oriented Programming Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Introduction to Computing (CSC01), Data Structures and		CT+EA [CT: 60%, ET(Laboratory assignment + Viva Voce): 40%]					

<table>
<tr><td colspan="2">Algorithms (CSC303)</td></tr>
<tr><td>Course Outcomes</td><td>CO1: Understanding existing problems in terms of object oriented methodologies and design codes using OOL syntax
CO2: Derive solutions using the concepts of classes and objects.
CO3: Design and implement programs using various forms of inheritance
CO4: Learn different forms of polymorphism and derive solution for related problems
CO5: Implementation of templates and exception handling
CO6: Solving mini projects using the concepts of object oriented technology</td></tr>
<tr><td>Topics Covered</td><td>Assignment 1: Design codes using OOL syntax; use of manipulators, dynamic allocation, multi-dimensional array writing application like addition, subtraction, multiplication, finding factorial of a large numbers etc.
Assignment 2: Develop codes involving binary and text files involving string manipulation, graph processing, etc.
Assignment 3: Design class library for implementing matrix, complex number, string, stack, queue, linked list, heap, binary search tree, polynomial, etc.
Assignment 4: Develop class library to implement application like hashing, huffman code, expression evaluation using the libraries developed in assignment 3.
Assignment 5: Enhance the class libraries in assignment 3&4 implementing function overloading.
Assignment 6: Enhance the class libraries in assignment 3&4 implementing operator overloading.
Assignment 7: Develop codes using inheritance.
Assignment 8: Design and develop template classes.
Assignment 9: Implement exception handling in some existing template classes .</td></tr>
<tr><td>Text Books, and/or reference material</td><td>Text Books:
Bruce Eckel, “Thinking in C++”, Prentice Hall.
S. B. Lippman, J. Lajoie, B. E. Moo, “C++ Primer”, Addison-Wesley Professional
Bjarne Stroustrup, “Programming: Principles and Practice Using C++”, Addison-Wesley Professional.
Effective C++: 50 Specific Ways to Improve Your Programs and Design by Scott Meyers, 1997.
More Effective C++ by Scott Meyers, 2002.
Others:
NPTEL course link by Prof. Partha Pratim Das - https://onlinecourses-archive.nptel.ac.in/noc19_cs10/preview</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	2	1	1	-	-	1	-	1
CO2	-	3	3	3	3	1	2	-	-	-	1	-
CO3	-	3	3	3	3	-	1	-	-	-	1	-
CO4	2	3	3	3	3	-	1	-	-	-	2	-
CO5	-	3	3	3	3	-	-	-	1	1	3	-

CO6	3	3	1	3	2	3	2	3	3	3	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 453 Signals and Systems Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 453	Signals and Systems Laboratory	PCR	0	0	3	3	1.5
Pre-requisites:		Course Assessment methods (Continuous (CT) and End assessment (EA))					
MATLAB, Python		CT+EA [CT: 60%, ET(Laboratory assignment + Viva Voce): 40%]					

Course Outcomes

- CO1: Simulate signals and systems using modern computer software packages (Matlab/Python).
- CO2: Apply Laplace transform, Fourier transform, Z-transform and other mathematical operations for the purpose of analyzing signals and systems.
- CO3: Design and analysis of continuous and discrete time systems.
- CO4: Compare continuous time and discrete time systems in real life applications.

Topics Covered

1. Introduction to Computer Software Package Matlab/Python
2. Simulation of standard of signals like
   a. Unit step
   b. Unit impulse
   c. Ramp
   d. Periodic sinusoidal sequences.
3. Basic operation on signals: Addition, Subtraction, Multiplication, Division, shifting, scaling, etc.
4. Convolve and analyze signals in time domain.
5. Laplace transform and inverse Laplace transform of signals.
6. Convolution of signals in transformed domain and verification of convolution property of Fourier and Z-transform.
7. Study of LTI system and its stability.
8. Design of Stable LTI systems.
9. Design of FIR and IIR systems.
10. Implement Fast Fourier Transform algorithm of a signal.

Text Books, and/or reference material

Text Books:

1. Signals and Systems Laboratory with MATLAB, Alex Palamides and Anastasia Veloni, CRC Press, 2011.

Reference Books:

2. Anywhere-Anytime Signals and Systems Laboratory, Nasser Kehtarnavaz, Fatemeh Saki, Morgan & Claypool, 2017.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	3	-	-	-	-	-	-	2
CO2	2	3	3	3	-	-	-	-	-	-	-	2
CO3	2	3	3	3	-	1	-	-	-	-	-	2
CO4	2	2	2	2	-	1	-	1	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

CSC 501 Operating Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 501	Operating Systems	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Computer Organization and Architecture (CSC401),Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**

Course Outcomes	● CO1: Explain the functional architecture of an operating system. ● CO2: Design the process control algorithms, solution to deadlocks and multi-threading applications ● CO3: Implement application programs using UNIX system calls. ● CO4: Design and solve control & data access synchronization problems. ● CO5: Explain virtual memory organization and management in OS. ● CO6: Implantation of standard FAT & UNIX file system.
Topics Covered	**Introductory Concepts:** Introduction to Operating System as a whole, memory, CPU(registers and ALU), Evolution of Operating System-types of OS(advantages and drawbacks), Performance measurement metrics. (3L) **Process Data Structures and State transitions:** Process management, Basic Definitions, Process table, PCB(process control block), PTE(process table entry), Process states, Transition diagram, context of process-user level, kernel-level and process Level. (3L) **Process Control:** Process creation, Parent and Child processes, System calls--fork(), exit(), wait(), kill(), Signal handling, Process scheduling strategies-FCFS, SPN, SRT, Round Robin, HRRN, Fair share scheduling. (5L) **Multi-threading:** Threads in OS, thread vs process, ULT & KLT, Applications of threads, Use of POSIX threads library. (3L) **Process synchronization -** Race condition, Critical section, Process Sync Solution using Algorithmic approach (Lamport bakery Algorithm), Creating shared memory using POSIX library. (2L) **Semaphore**- Binary and Counting semaphore, P() and V() operations, Solving Classical problem using semaphores- Sleeping barber, Producer-consumer, Reader-writer, Dining philosophers's problem, Posix library for semaphores. (6L) **Monitors** - Solving Classical problems using monitors. (3L) **Deadlocks** - Necessary and sufficient conditions for deadlocks, approaches to deal with deadlocks, Deadlock Prevention, Avoidance (Banker's algorithm) and Detection. (3L)

	Memory organization & management - Virtual memory organization, Pure Paging, Pure Segmentation, Combined Paging-Segmentation, Inverted PMT, Page fault handling algorithms, Working set theory. (7L) **File management**- Directory structure, Storage of files on disks, contiguous and non-contiguous file allocation strategies, Internal and external fragmentation, FAT & Inode Structure, Free Space management, Disk scheduling strategies. (5L) **I/O management concepts** (2L)
Text Books, and/or reference material	**Text Books:** 1. “Operating System Concepts”, Silberschatz and Galvin. 2. “Operating Systems: Internals and Design Principles” by William Stalling. 3. “Operating Systems: A Concept-Based Approach” by D M Dhamdhere. **Reference Books:** 1. “Operating System: A Design-oriented Approach” by Charles Crowley. 2. “Operating Systems: A Modern Perspective” by Gary J Nutt. 3. “Design of the Unix Operating Systems” by Maurice Bach. 4. “MODERN OPERATING SYSTEMS” by Andrew S Tanenbaum. **Others:** • https://nptel.ac.in/courses/106/106/106106144/#Course “Introduction to Operating Systems” by PROF. CHESTER REBERIO, IIT Madras. • https://nptel.ac.in/courses/106105214/ Course “Operating System Fundamentals” by Prof. Santunu Chattopadhyay, IIT Kharagpur.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	1	3	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	1
CO5	1	2	2	3	3	1	-	-	-	1	3	1
CO6	-	-	3	-	3	3	2	-	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 502 Database Management System 3-1-0 4 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 502	Database Management System	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Programming knowledge, Data Structures and Algorithms	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	• CO1: Understand the basic concepts and appreciate the applications of database systems. • CO2: Comprehend the fundamentals of design principles for logical design of relational databases. • CO3: Apply the query writing skill and its subsequent optimization. • CO4: Understand the basic issues of transaction processing and concurrency control.
Topics Covered	**Introduction:** Concept & Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS. (4L) **Entity-Relationship Model:** Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram, Weak Entity Sets, Extended E-R features. (5L) **Relational Model:** Structure of relational Databases, Relational Algebra, Relational Calculus, Extended Relational Algebra Operations, Views, Modifications of the Database. **(7L)** **SQL and Integrity Constraints:** Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, assertions, views, Nested Subqueries, Database security application development using SQL, Stored procedures and triggers. (7L) **Index Structures:** Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes, Dynamic Multilevel Indexes using B tree and B+ tree . (4L) **Normalization:** Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Fourth Normal form and fifth normal form, normalization and database design, Denormalization, Loss-less join decomposition, Dependency preservation. (8L) **Transaction processing:** Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability. (5L) **Concurrency Control:** Serializability: Enforcing, Serializability by Locks, Locking Systems With Several, Lock Modes, Architecture for a Locking Scheduler Managing Hierarchies of Database Elements, Concurrency Control by Timestamps, Concurrency Control by Validation. (5L) **Database recovery management:** Deferred database modification Vs. Immediate

	database modification, Check point technique. (3L) **Query Optimization:** Heuristics in Query Optimization, Converting Query Tree to Query Evaluation Plan. (4L) **Distributed Database (DDB):** Introduction of DDB, DDBMS architectures, Homogeneous and Heterogeneous databases, Distributed data storage, Advantages of Data Distribution, Disadvantages of Data Distribution Distributed transactions, Commit protocols, Data Replication, Data Fragmentation. Distributed database transparency features. (4L)
Text Books, and/or reference material	**Text Books:** 1. "An Introduction to Database Systems", C. J Date, Pearson Education. 2. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 3. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:** 1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley. **Others:** https://onlinecourses-archive.nptel.ac.in/noc18_cs15/preview

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	1	1	1	1	1	2	2
CO2	3	3	3	3	2	1	1	-	-	2	2	2
CO3	2	3	3	3	2	1	1	-	-	2	2	2
CO4	3	2	2	2	1	1	1	1	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 503 Compiler Design 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC 503	Compiler Design	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Theory of Computing/ Theory of Automata		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course	• CO1: Idea of the difference between Compiler and other various						

Outcomes	Translators, Phases of a Compiler and Bootstrapping. ● CO2: Understand Lexical Analyzer, Transition Diagram of different tokens, Reserved Word Strategy. ● CO3: Idea of Syntax Analyzer, Ambiguity, Parse Tree, Top Down and Bottom Up Parser. ● CO4: Concept of Semantic Analyzer, Semantic Actions, Intermediate Code, Virtual Machine. Lexical and Grammatical Errors. ● CO5: Idea of Code Optimization, Criterion of Optimization, Different Local and Global Optimization Techniques. ● CO6: Idea of Code Generation, Instruction Costs, Code Generation Algorithm, Run Time Store Management.
Topics Covered	Idea of the difference between Compiler and other various Translators, Phases of a Compiler and Bootstrapping. (5L) Understand Lexical Analyzer, Transition Diagram of different tokens, Reserved Word Strategy. (5L) Idea of Syntax Analyzer, Ambiguity, Parse Tree, Top Down and Bottom Up Parser. (6L) Concept of Semantic Analyzer, Semantic Actions, Intermediate Code, Virtual Machine. Lexical and Grammatical Errors. (7L) Idea of Code Optimization, Criterion of Optimization, Different Local and Global Optimization Techniques. (7L) Idea of Code Generation, Instruction Costs, Code Generation Algorithm, Run Time Store Management. (7L) Symbol Table Design, Fixed Length and Variable Length Entry, Symbol Table Actions, Different Searches, Hash Table Organization, Different Deletions of Symbols, Linked List and Tree Representation. (5L)
Text Books, and/or reference material	**Text Books:** 1. Principles of Compiler Design – Alfred V. Aho & Jefrey D. Ullman, Pearson Education. **Reference Books:** 1.Compiler Design in C – Holub, Prentice Hall.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	2	-	-	-	-	-	-	3
CO2	2	3	3	2	2	-	-	-	-	-	-	3
CO3	2	2	3	2	2	-	-	-	-	-	-	3
CO4	2	2	3	3	2	-	-	-	-	-	-	3
CO5	3	2	3	3	2	-	-	-	-	-	-	3
CO6	3	2	3	3	2	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 504 Embedded Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC504	Embedded Systems	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Computer Organization and Architecture (CSC401)	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**

Course Outcomes

- CO1:. Understand the Building Blocks of Embedded Systems
- CO2 : Learn to implement circuits using FPGAs and HDL programming
- CO3 :. Learn the working of microcontrollers in building embedded systems.
- CO4 : Understand the importance of power in the design process.
- CO5 : Understand the concepts and constraints of realtime systems.
- CO6 : Learn the techniques of synthesising hardware design from HDL.

Topics Covered

UNIT-1

Introduction to embedded System, Modular approach to embedded system design using six-box approach: Input devices, output devices, embedded computer, communication block, host and storage elements, and power supply., Processor, General Purpose and ASICs Processor, Designing a single purpose processor, Optimization Issues

6L

UNIT-2

Introduction to FPGA, Behavioral synthesis on FPGA using VHDL/Verilog

4L

UNIT-3

Microcontroller based embedded system Design, Salient feature of modern microcontroller, Arduino Uno, Serial Communication and Timer, Controller Design using Arduino

5L

UNIT-4

Sensors and Signals, Discretization of signals and A/D Converter, Quantization Noise, SNR and A/D converter,

5L

UNIT-5

Power Aware Embedded System, SD and DD Algorithm, Parallel operations and VLIW, Code efficiency, DSP Application and address generation Unit

6L

UNIT-6

	Real time operating system, RMS Algorithm, EDF Algorithm and resource constraint issue, Priority inversion and Priority inheritance 5L UNIT-7 Modelling and specification, FSM and state chart, state mate semantics, Program state machine, SDL, Data flow model 5L UNIT-8 Hardware synthesis, Scheduling, Digital camera design, Digital camera-iterative design, HW-SW partitioning, Optimization, Simulation, Formal verification 6L
Text Books, and/or reference material	**Text Books:** 1. Mazidi and Mazidi, Microcontroller and Embedded Systems, Pearson Education. 2. Peter Marwedel, Embedded System Design, Kluwer. 3. Wayne Wolf, Computers as Components: Principles of Embedded Computing Systems Design, Morgan-Kaufmann. 4. Frank Vahid and Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, John Wiley. **Reference Books:** 1. R. Kapadia, 8051 Microcontroller and Embedded Systems, Jaico. 2. Peatman,J.B., “Design with PIC Micro Controllers”PearsonEducation,3rdEdition, 2004. 3. Furber,S., “ARM System on Chip Architecture” Addison Wesley trade Computer Publication, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	1	-	-	1
CO2	3	3	3	1	1	-	-	-	1	-	-	1
CO3	3	3	3	1	1	-	-	-	-	-	-	-
CO4	3	2	2	1	1	-	-	-	-	-	-	-
CO5	3	3	3	1	1	-	-	-	-	-	-	-
CO6	2	2	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 551 Design and Analysis of Algorithms Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 551	Design and Analysis of Algorithms	PCR	0	0	3	3	1.5

	Laboratory
Pre-requisites	Course Assessment methods (Continuous (CT) and End assessment (EA))
Design and analysis of Algorithm (CSC 503), Data Structures and Algorithms Laboratory (CSS 352)	CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]
Course Outcomes	After completion of this course, the students will be: ● CO1: Able to identify the essence of theory into implementation. ● CO2: Able to interpret the theory efficiently through coding. ● CO3: Able to verify the theory experimentally. ● CO4: Able to explain the behaviour of an algorithm efficiently. ● CO5: Able to compare the efficiency of different algorithms.
Topics Covered	**Assignment 1:** Exponential versus Polynomial Running time solution of a problem. **Assignment 2:** Heaps and priority queue. **Assignment 3:** Problem based on Linear time sorting algorithm. **Assignment 4:** Problem using Divide and Conquer algorithm. **Assignment 5:** Problem using Greedy algorithm. **Assignment 6:** Problem using Dynamic Programming algorithm. **Assignment 7:** Graph representation and traversal. **Assignment 8:** Problem using Union Find structure. **Assignment 9:** Problem using Interval tree. **Assignment 10:** Convex Hull computation from a given set of n points in 2D and then determining the farthest pair of these point set.
Text Books, and/or reference material	**Text Books:** 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, by Prentice Hall India. 2. J. Kleinberg and Eva Tardo, Algorithm Design by Pearson Education (Indian edition). **Reference Books:** 1. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Wiley, 2006. 2. S. Dasgupta, C. Papadimitriou and U. Vazirani, Algorithms, by Tata McGraw-Hill. **Others:** The Algorithm Design Manual 2nd ed. 2008 Edition by Steven S S. Skiena, Springer.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	3	-	-	-	1	1	-	3
CO2	2	2	3	3	3	-	-	1	2	1	1	3
CO3	2	2	2	3	3	-	-	1	1	2	1	3
CO4	2	3	3	2	1	1	-	-	-	3	1	3
CO5	2	2	3	3	3	1	1	2	2	2	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 552 Embedded System Design Laboratory 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 552	Embedded Systems Laboratory	PCR	0	0	3	3	1.5
Pre-requisites			Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))				
CSS 451 Computer Org. Laboratory			CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]				

Course Outcomes	After the course the students are expected to be able to CO1: Learn the working of microcontroller. CO2 : Understand the Building Blocks of Embedded Systems CO3 : Learn to implement circuits using FPGAs and HDL programming. CO4 : Learn to solve problems using Arduino/Raspberry Pi CO5 : Know the characteristics ARM processor and use it in designing embedded systems.
Topics Covered	List of Experiments: 1. Familiarization with 8051 microcontroller based programming. 2. Interfacing of 8051 Microcontroller with ADC and DAC/LCD Display/Traffic signal Processing etc. 3. Simulating simple circuits using Verilog/VHDL and FPGA kits. 4. LED blink for different amounts of time using Arduino (with/without using delay() function). 5. Controlling the LED blinking using a Potentiometer (Read potentiometer). 6. Interfacing Arduino with simple LED Matrix. 7. Sensing temperature using Raspberry Pi. 8. Familiarization with ARM DEVELOPMENT KIT microcontroller using embedded C program. 9. Develop and verify the interfacing LED and PWM with ARM DEVELOPMENT KIT microcontroller using embedded C program 10. Develop and verify the interfacing of real time clock and serial port with ARM DEVELOPMENT KIT microcontroller using embedded C program. 11. Verify the Interrupt performance characteristics of ARM and FPGA by using embedded C program
Text Books, and/or reference material	**Text Books:** 1. Peatman,J.B., "Design with PIC Micro Controllers"PearsonEducation,3rdEdition, 2004. 2. Programming Arduino: Getting Started with Sketches Book by Simon Monk 3. R. Kapadia, 8051 Microcontroller and Embedded Systems, Jaico.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	1	-	-	1
CO2	2	2	2	2	2	-	-	-	-	-	-	-
CO3	2	2	1	-	-	-	-	-	1	-	-	-
CO4	3	3	3	3	3	-	-	-	1	-	-	1
CO5	2	2	2	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 553 Operating Systems Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 553	Operating Systems Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	• CO1: Implement elementary UNIX system commands. • CO2: Devise programs to test synchronization problems. • CO3: Design and develop user level thread library. • CO4: Design and implement file system.						
Topics Covered	**Assignment 1**: Getting a feel of race conditions through read/write operations by multiple process (run the same program in four terminals simultaneously) on a single binary file. **Assignment 2**: Design application where the parent process uses fork system call to create multiple child processes in the different given hierarchy and displaying and storing the process hierarchy in a separate file. **Assignment 3**: Design application where parent sync with several child processes using fork & wait system call to solve a particular task (searching, prime number generation, etc.) like parallely also try to understand and change process priorities using system calls. **Assignment 4**: Implement signal handling among parent child processes. **Assignment 5**: Design multithreaded application using POSIX thread library. **Assignment 6**: Create shared memory to be used among a set of concurrent processes using POSIX library. **Assignment 7**: Implement semaphores (named) and solve data access sync						

	problems like (producer/consumer) using multiple processes. **Assignment 8**: Implement semaphores (unnamed) and solve data access sync problems like (producer/consumer) using multiple threads. **Assignment 9**: Use other IPC mechanisms like message queues, named pipe.
Text Books, and/or reference material	**Text Books:** "Beginning Linux Programming", 4th Edition by Richard Stones, Neil Matthew, Wiley Publishing, Inc. **Reference Books:** "Advanced Programming in the UNIX environment", 3rd Edition, W. Richard Stevens and Stephen A. Rago, Addison-Wesley, 2013.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	3	3	2	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	2	1	-	-	-	1	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

HSC 631 Economics and Management Accountancy 3-0-0 3 Credits 3 Hrs

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	Economics and Management Accountancy	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes

- CO1 Learners will be able to review basic economic principles.
- CO2 Learners will be introduced to the basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works.
- CO3 Learners will gain a good knowledge of financial accounting, enabling them prepare, analyse and interpret financial statements for taking informed decisions.

Topics Covered

PART 1: Economics

Group A: Microeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Economics: Basic Concepts	2	0	0	2	2
Unit 2:	Theory of Consumer Behaviour	3	0	0	3	3
Unit 3:	Theory of Production, Cost and Firms	3	0	0	3	3
Unit 4:	Analyses of Market Structures: Perfect Competition	3	0	0	3	3
Unit 5:	Monopoly Market	2	0	0	2	2
Unit 6:	General Equilibrium & Welfare Economics	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

Group B: Macroeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Macroeconomic Theory	2	0	0	2	2
Unit 2:	National Income Accounting	3	0	0	3	3
Unit 3:	Determination of Equilibrium Level of Income	4	0	0	4	4
Unit 4:	Money, Interest and Income	2	0	0	2	2
Unit 5:	Inflation and Unemployment	2	0	0	2	2
Unit 6:	Output, Price and Employment	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

	PART 2: Management Accountancy						
	Sl. No.	**Name**	**L**	**T**	**P**	**Cr**	**H**
	Unit 1:	**Introduction to Accounting**: Accounting Environment of Business; Objectives of Accounting; Accounting Equations for Financial Statements. Books of Accounting: Journal, Ledger, Cash book.	3	0	0	3	3
	Unit 2:	**Financial Statement Preparation and Analysis:** Preparation of Trial Balance, Trading, Profit & Loss account and Balance Sheet. Case study discussion.	5	0	0	5	5
	Unit 3:	**Financial Ratio Analysis:** Common Size Statements; Computation of Financial Ratios; Interpretation and analysis of Financial Ratios with the help of case studies.	4	0	0	4	4
		TOTAL	**12**	**0**	**0**	**12**	**12**
Text Books, and/or reference material	**PART 1: Economics** **Group A: Microeconomics** 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics **Group B: Microeconomics** 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. Soumyen Sikder: Principles of Macroeconomics **PART 2: Management Accountancy** 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.						

CO-PO MAPPING of Economics and Management Accountancy (HSC631)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	-	-	-	1	-	-	-	-	-	2	3	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSC 601 Software Engineering 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 601</td><td>Software Engineering</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: How to apply the software engineering lifecycle by demonstrating competence in communication, planning, analysis, design, construction, and deployment.
CO2:An ability to work in one or more significant application domains to develop and deliver quality software..
CO3:Demonstrate an understanding of and apply current theories, models, and techniques that provide a basis for the software lifecycle.
CO4: Demonstrate an ability to use the techniques and tools necessary for software engineering practices.</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Software Paradigm / Introduction</u>: Definition of Information System, software, software engineering paradigms, Software engineering in context of Business Process Engineering, Goal of Software Engineering, Quality focus. (2L)
<u>Software Process Model</u>: Umbrella activities; Waterfall Model, Prototype model, Rapid Application Development Model, Evolutionary Approach in Process model (Spiral Model). (4L)
<u>Requirement Engineering</u>: Requirements Engineering Tasks, Information Modelling (Entity Relationship Model, Extended ER Model), Functional Model (DFD, CFD), Behavioral Model (State Transition Diagram), Petri-net modelling, System Requirement Specification (SRS), Specification Language – Formal Methods, Regular Expression, Decision Tree, Decision Table, SRS Standards. (6L)
<u>Design Principle and Basics</u>: Design level tasks, Problem partitioning, abstraction, top down & bottom up design strategies, refinement techniques, Minor Design principles, Control Hierarchy (Structured Chart), constraint design (Warnier –Orr). (2L)
<u>Design Language basics</u>: Unified Modelling Language – Building Blocks, Well-formedness rule; Use case, structural diagram introduction - Class Diagram, Object Diagram, Sequence diagram, collaboration diagram. (6L)
<u>Modular Design</u>: Concept of module and Modular design, Functional independency, Cohesion, Coupling, measuring cohesion and coupling, Model Driven Architecture. (4L)
<u>Architecture Basic</u>: Software architecture, Functional and extra-functional properties, families of related system, Architectural styles: Data-centric, data-</td></tr>
</table>

	flow, call and Return, layered, enterprise. (2L) *Project Management*: LOClFunction Point Analysis PERT Chart estimation, Different cost estimation: Delphi-empirical-COCOMO estimation. (2L) *Coding Techniques & Standard guidelines*: Rules/guidelines for standard Coding l Gunning Fog Index for documentation. (2L) *Testing strategy 1*– Introduction to Software Testing, Software Testing Terminology and Methodology Verification and Validation, Static Testing: Inspections, Structured Walkthroughs, Technical Reviews l Dynamic Testing: Black-Box Testing Techniques: Boundary Value Analysis (BVA), Equivalence Class Testing, State Table-Based Testing, Decision Table-Based Testing, Cause-Effect Graphing Based Testing, Error Guessing Dynamic Testing : White-Box Testing Techniques: Need of White-Box Testing, Logic coverage Criteria, Basis Path Testing, Graph Matrices, Loop Testing, Data Flow Testing.(6L) *Testing strategy 2*- Validation Activities: Unit Validation Testing, Integration Testing, Function Testing, System Testing, Acceptance Testing lRegression Testing: Progressive vs Regressive Testing, Regression Testability. (2L) *Software & Metrics:* Software Measurement & metrics, Direct and indirect metrics, Size oriented metrics, Function oriented Metrics, Complexity Metrics – McCabe Complexity, McClure Complexity, and Halstead Software Science (4L) Standard Software Engineering Practices: IS 16458 and IS 16443 recommendations. (2L).
Text Books, and/or reference material	**Text Books:** R. S. Pressman -"Software Engineering – Practitioner's Approach"- McGraw Hill International. I. Somerville – "Software Engineering", Addison-Wesley **Reference Books:** Rajib Mal - "Fundamental of Software Engineering", PHI. **Others:** Unified Modelling Language, Object Management Group, http://www.omg.org/spec/UML/

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	1	1	1	1	1	1	2	2
CO2	3	3	3	3	2	2	2	1	1	2	2	2
CO3	3	3	3	3	3	2	1	1	2	2	2	3
CO4	3	2	3	2	1	1	1	1	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

CSC 602 Data Communication and Computer Networks 3-1-0 4 Credits 4 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 602</td><td colspan="2">Data Communication and Computer Networks</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Data Structures and Algorithms, Operating system concepts</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Understand the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model.
CO2: Comprehend the fundamentals of Physical layer, and will apply them in real time applications.
CO3: Identify data link layer concepts, design issues, and protocols.
CO4: Classify the routing protocols and analyze how to assign the IP addresses for the given network.
CO5: Acquire knowledge of Application layer and Presentation layer paradigms and protocols.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Overview of Data Communication and Networking: Introduction; Data communications: components, data representation (ASCII,ISO etc.), direction of data flow (simplex, half duplex and full duplex); network criteria, physical structure (type of connection, topology), categories of network (LAN, MAN,WAN); Internet: brief history, Protocols and standards; Reference models: OSI reference model, TCP/IP reference model, their comparative study. (4L)

Physical Level: Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus; Telephone Network. (6L)

Data link Layer: Types of errors, framing (character and bit stuffing), error detection & correction methods; Flow control; Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, HDLC; Medium Access sublayer: Point to Point Protocol, LCP, NCP, Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA, Traditional Ethernet, Fast Ethernet. (12L)

Network layer: Internetworking & devices: Repeaters, Hubs, Bridges, Switches, Router, Gateway; Addressing: IP addressing, subnetting; Routing: techniques, static vs. dynamic routing, Unicast Routing Protocols: RIP, OSPF, BGP; Other</td></tr>
</table>

	Protocols: ARP, IP, ICMP, IPV6, Congestion Control: Open Loop, Closed Loop choke packets; Quality of service: techniques to improve QoS: Leaky bucket algorithm, Token bucket algorithm. (14L) **Transport layer:** Process to Process delivery; Socket address, UDP; TCP. (4L) **Application Layer:** Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW. (4L) **Security:** Threats analysis,Cryptography (Public, Private Key based), Digital Signature, authentication, access control, security standards like TLS, IS/ISO 27000 series and IS/ISO 18000 (6L) **Modern topics:** Introduction to Wireless Technology, Introduction to Software Defined networking (SDN). (4L) **Queuing Theory:** Introduction to Queuing Theory and Delay Analysis for networks. (2L)
Text Books, and/or reference material	**Text Books:** 1.B. A. Forouzan – "Data Communications and Networking (3rd Ed.) " – TMH. 2. A. S. Tanenbaum – "Computer Networks (4th Ed.)" – Pearson Education/PHI. **Reference Books:** 3. Comer – "Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.)" – Pearson Education/PHI.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	1	1	1	1	2	2	2
CO2	2	2	1	1	1	1	1	1	1	1	2	2
CO3	2	2	3	2	2	1	1	1	1	1	1	2
CO4	3	3	3	3	2	2	2	1	1	2	2	2
CO5	2	2	2	2	2	1	1	2	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 651 Compiler Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS651	Compiler Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Compiler Design Theory of Computation CSC402		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	● CO1: To apply the concept of regular expressions in the identification of tokens in a lexical analyzer.						

	• CO2: To explore the use of program generating softwares like LEX and FLEX. • CO3: To generate context -free grammar to represent the syntax of the language. • CO4: To use compiler generators like YACC and BISON. • CO5: To use syntax directed translation to generate intermediate code.
Topics Covered	1. Handle tokens in an input using LEX generated program. 2. Describe class of tokens using regular expressions in LEX. 3. Use context free grammars with YACC to describe simple syntactic structures. 4. Remove ambiguity in if-then-else constructs using YACC's inbuilt features. 5. Use syntax directed translation in YACC to generate simple intermediate code.
Text Books, and/or reference material	**Text Books:** 1. Lex - A Lexical Analyzer Generator ***M. E. Lesk and E. Schmidt*** Online Manual. 2. Yacc: Yet Another Compiler-Compiler ***Stephen C. Johnson*** Online Manual. 3. Lex & Yacc*John R. Levine, Tony Mason, Doug Brown* , O'Reilly & Associates. **Reference Books:** **1. Compilers: Principles, Techniques, and Tools** By Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman. Addison-Wesley Pub Co.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	-	-	-
CO2	2	3	3	2	3	-	-	-	-	-	-	-
CO3	3	3	3	2	2	-	-	-	-	-	-	-
CO4	2	3	3	2	3	-	-	-	-	-	-	-
CO5	3	2	3	2	3	-	-	-	-	-	-	-

Mapping of CO (Course Outcome) and PO (Programme Outcome)
Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 652 Data Communication and Computer Networks Laboratory 0-0-3 1.5Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 652	Data Communication and Computer Networks Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End					

	assessment (EA))
Operating System Laboratory	CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]
Course Outcomes	• CO1: Develop programs for client-server applications. • CO2: Perform packet sniffing and analyze packets in network traffic. • CO3: Implement error detecting and correcting codes.
Topics Covered	Assignment 1 : Packet capturing and analyzing using wireshark packet sniffer tool Assignment 2 : Socket Programming for TCP client server (Iterative server). Assignment 3 : Socket Programming for TCP client server (Concurrent Server). Assignment 4 : Socket programming for UDP client. Assignment 5 : Handling both TCP client and UDP client using select() system call. Assignment 6 : Simplified FTP implementation. Assignment 7 : Two player game (Tic Tac Toe) implementation. Assignment 8 : Implementation of CRC and Hamming code for error handling Assignment 9 : RPC (Remote Procedure Call) implementation.
Text Books, and/or reference material	**Text Books:** 1. Richard Stevens, Unix Network Programming, Volume 1 and 2, Addison-Wesley Professional. **Reference Books:** 1. Neil matthew and Richard Stones, Beginning Linux Programming, Wrox Publishers, 4th Edition.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	-	-	1	1	1	2	2
CO2	2	2	2	2	2	-	-	1	1	1	2	2
CO3	2	2	2	2	2	-	-	1	1	1	2	2

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 653 Database Management System Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 653	Database Management System Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Programming knowledge, Data structure knowledge		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					

Course Outcomes	• CO1: Understand, appreciate and effectively explain the underlying concepts of database technologies. • CO2: Design and implement a database schema for a given problem-domain. • CO3: Populate and query a database using SQL DML/DDL commands. • CO4: Programming PL/SQL including stored procedures, stored functions, cursors, packages.
Topics Covered	**Structured Query Language (SQL):** 1. Creating Database Creating a Database Creating a Table Specifying Relational Data Types Specifying Constraints Creating Indexes. 2. Table and Record Handling INSERT statement Using SELECT and INSERT together DELETE, UPDATE, TRUNCATE statements DROP, ALTER statements. 3. Retrieving Data from a Database The SELECT statement Using the WHERE clause Using Logical Operators in the WHERE clause Using IN, BETWEEN, LIKE, ORDER BY, GROUP BY and HAVING Clause Using Aggregate Functions Combining Tables Using JOINS Subqueries. 4. Database Management Creating Views Creating Column Aliases Creating Database Users Using GRANT and REVOKE. **PL / SQL:** Decision-control in PL / SQL, Cursors in PL / SQL, Stored Procedures. **Case Studies:** Real-life case studies.
Text Books, and/or reference material	**Text Books:** SQL, PL/SQL the Programming Language of Oracle by Ivan Bayross**,** PHI, 2010. **Reference Books:** SQL The Complete Reference, Groff James, 3rd Edition, Tata McGraw-Hill Education, India.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	2	1	1	1	1	1	1	2
CO2	2	3	3	2	2	1	1	1	1	1	1	2
CO3	2	3	3	2	2	1	1	1	1	1	1	2
CO4	2	3	3	2	2	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Depth Elective – 1, 2

CSE 612 System Software 3-0-0 3 Credits 3Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE612	System Software	PEL	3	0	0	3	3
Pre-requisites: Programming		Course Assessment methods (Continuous Assessment (CA), Mid-					

Language Paradigms, Theory of Computing, Computer Architecture, Operating Systems, Compilers	Term (MT), End Term (ET))
	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	● CO1: To introduce the students to the collection of programs and procedures which constitute the system software of a computer platform. ● CO2: To allow the students to understand & acknowledge the main objectives, problems faced and programming techniques used by a system programmer in designing and implementing system software. ● CO3: To emphasize on the conceptual framework in which the system software is developed and used rather than a broad overview of programs which belong to the system software running on a particular computer platform. ● CO4: To enable the students to deduce the logical relationship between the software components of any software system. ● CO5: To enable students to understand the mechanism of Integration of different System Software components.
Topics Covered	Part I: The Methodology ● The fundamental objective of this part is to develop a concept of a System. ○ Concept is to be built upon both Mathematical construction(Algebraic and Logic Systems) as well as around construction based on Abstract Machines. (3L) ● Programs and documents that are part of System Software are to be defined. (1L) ● A structuring of System Software Components are to be defined and built. ○ Vertical Structuring: Components of the system software are layered on a hierarchy of levels. The hardware system is taken as the first level of this hierarchy. The interface relationship between the components of the system software vertical hierarchy is then established. (2L) ○ Horizontal Structuring: Each level of the system software vertical hierarchy is discussed as a horizontal structure. The elements of this horizontal structure (formal definitions will also be given) are specific software components of the system software organized as software systems. (2L) ● The specific problems posed by the interaction between the software system components of a horizontal level of the system software hierarchy are discussed and illustrated. The problems raised by the **reliability, efficiency, convenience**, and evolution of a system software are introduced and illustrated. (2L) Part II: Programming Support Environment: ● of a System Software is to be discussed as the collection of tools offered by a computer platform to computer users to help them use the computer to develop programs that solve their problems. (2L) ● Detailed discussions on Topics like: Language, Translators, Interpreters, Mechanism of target machine code generation; proper emphasis on

distinguishing between Compilers, Assemblers, Linker/Loaders, and Interpreters will be there. Interfacing users with the Operating System environment as tolls from the support environment is to be discussed. (6L)

- Case study of JVM, GNU GCC implementation of the Linux Assembler, Linker and Loader will be dealt with in detail, introducing implementation of symbol tables. (7L)

Part III: Execution Support Environment:

- A software system that manages computer resources of the computer platform and the processes running on the computer platform will be introduced and illustrated by the operating system. (3L)
- The components of the operating system itself are layered on the levels of a hierarchy. (2L)
- The mechanism of a system call (system function call) will be discussed as a tool for implementing this hierarchy relation. (2L)
- The following layers of an operating system will be discussed with a practical illustration with the Linux kernel, with mechanisms of designing system programs developed with and for the support of: (10L)
  - Interrupt System ⇔ designing interrupt handlers.
  - Process Management System ⇔ designing schedulers.
  - Memory Management System ⇔ designing page-fault exception handlers
  - Input/Output Management System ⇔ designing device drivers
  - Information Management System (File System) ⇔ examining ext2/ext3/ext4.

Text Books, and/or reference material

Text Books:

1. System Software and Software Systems: Systems Methodology for Software, Tudor Rus, World Scientific Press, 1993.
2. System Software: An Introduction to Systems Programming, leyland L. Beck, 1996.
3. System Programming with C and Unix, Adam Hoover, Adison Wesley 2010.

Reference Books:

1. Understanding the Linux Kernel, Daniel P. Bovet, Marco Cesati, O'Reilly Pub Date:November 2005.
   Available online at:
   http://johnchukwuma.com/training/UnderstandingTheLinuxKernel3rdEdition.pdf

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	-	2	-	-	-	-	-	-	-
CO2	2	3	3	3	3	-	-	-	-	-	-	-
CO3	2	2	-	3	2	-	-	-	-	-	-	-
CO4	-	3	-	3		-	-	-	-	-	-	-
CO5	-	3	-	2	3	-	-	-	-	2	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 613 Internet and Web Technologies 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE 613</td><td colspan="2">Internet and Web Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Programming Fundamentals, Data Structure and Algorithms, Operating Systems, Data networks (may be carried out simultaneously)</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Understanding the fundamental concepts of Internet Structure and Protocols.
CO2: Using TCP/IP protocols and Internet programming using SOCKET API.
CO3: Understanding HTTP protocol and Structures of Web Programming.
CO4: Designing and developing Web applications with security enhancement.
CO5: Understanding Semantic Web and Applying Web Analytics over Semantic Web.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">INTERNET TECHNOLOGY:
Brief review of Data Networking; data transmission, links and MACs, Forwarding and Routing, TCP-IP layered network concepts. (3L)
Internet specific issues like scalability, inter-operability. (1L)
Internet Structures – logical and physical grouping with sub-netting and super netting. (3L)
Review of TCP-IP protocols – processing, performance and variations. (3L)
Security Implementations - secured IP, Transport Layer security. (3L)
Quality of Service Issues and their Application in Internet. (2L)

SOCKET PROGRAMMING: Introduction to SOCKET API; Client programming; Server programming – sequential, concurrent and multi-threaded; P2P application Programming. (4L)</td></tr>
</table>

	HTTP: Requests and Responses - Message Formats, Headers and Fields; TCP Keep-alive and pipe-lining concepts; Server Architecture ,Performance and Deployment. (3L) WEB PROGRAMMING: Document Object Model; Client side scripting fundamentals: Server Side Scripting and Programming – Data base connectivity, session management and security enhancement; Introduction to Web Application Development Platforms – JavaEE, Dzango. (7L) XML: DTD and Schema; Visualisation using XSLT; Web Application using XML; Service Oriented Architecture and Web services based application development and deployment; Xquery and SOA based application development platforms. (6L) SEMANTIC WEB: General Concept of Semantic Web and linked Data; RDF based relation description; Web Ontology concepts and use; Putting XML, RDF and Ontology together to develop semantic web applications; Capturing Information from semantic web pages; Data analytics over semantic and linked Web. (7L)
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan, “TCP/IP Protocol Suite”, 4th Edition, 2010, McGrawHIll Publishers. 2. P. Deitel, H. Deitel, A Deitel, “Internet and World Wide Web – How to Program”, Pearson. 3. G. Antoniou, P. Groth, F. Harmelen and R. Hoekstra, “A Semantic Web Primer” Prentice Hall India. **Reference Books:** 1. D. E. Comer and D L Stevens, "Internetworking with TCP/IP vol.II", Pearson.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	3	2	1	1	2	-	-	1
CO2	2	2	-	-	3	1	-	-	1	-	-	-
CO3	1	1	-	-	3	2	2	2	3	1	1	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	3	2	2	3	2	-	2	3	-	-	2

Mapping of CO (Course Outcome) and PO (Programme Outcome)
Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 614 Advanced Computer Architecture 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 614	Advanced Computer Architecture	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Digital Electronics, Computer Organisation	CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]
Course Outcomes	• ·CO1: Understand classes of computers and interpret the performance of a processor based on different metrics. • CO2: Design and describe pipeline data-path for performance enhancement. • CO3: Understanding the challenges in realizing different levels of parallelism and leverage them for performance enhancement. • CO4: Design of memory hierarchy for efficient memory design. • CO5: Appreciate and evaluate the new trends and developments in computer architecture.
Topics Covered	OVERVIEW OF VON NEUMANN ARCHITECTURE: Instruction set architecture; The Arithmetic and Logic Unit, The Control Unit, Memory and I/O devices and their interfacing to the CPU; Measuring and reporting performance; CISC and RISC processors. (4L) PIPELINING: Pipelining fundamentals, Linear and Nonlinear Pipeline Processors, Arithmetic and instruction pipelining, Pipeline hazards, Techniques for overcoming or reducing the effects of various hazards, superscalar and super pipelined and VLIW architectures. (8L) INSTRUCTION –LEVEL PARALLELISM (ILP): Concepts and challenges of ILP; Compiler Techniques for exposing ILP; Branch costs reductions - Static and Dynamic predictions; Hardware-based speculation. (8L) MEMORY HIERARCHY DESIGN: Introduction; Memory technology and optimizations, Virtual memory, Cache memory, Cache performance; Cache Optimizations, Cache coherence, Cache coherence protocols – snoop based and directory based protocols, Advanced optimizations of cache performance. (10L)

	MULTIPROCESSORS ARCHITECTURES: Introduction; Taxonomy of parallel architectures, Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. (8L) INTERCONNECTION NETWORKS: Topology, Different interconnection Networks, Routing Mechanism. (4L)
Text Books, and/or reference material	**Text Books:** 1. Computer Architecture, A Quantitative Approach – John L. Hennessey and David A. Patterson; 4th edition, Morgan Kaufmann. 2. Advanced Computer Architecture Parallelism, Scalability, Programmability – Kai Hwang; Tata Mc-Graw Hill. **Reference Books:** 1. Computer architecture and parallel processing – Kai Hwang and FayéAlayé Briggs; McGraw-Hill. 2. Parallel Computer Architecture, a Hardware / Software Approach – David E. Culler, Jaswinder Pal Singh, Anoop Gupta; Morgan Kaufman. 3. John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw-Hill. 4. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House. **Others:** NPTEL/MOOC Courses materials.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	2	-	1	-	-	-	-	1
CO2	3	3	3	2	2	-	1	-	-	-	-	1
CO3	3	3	2	3	3	-	1	-	-	-	-	2
CO4	2	3	3	2	3	-	2	-	-	-	-	1
CO5	3	3	3	3	3	-	-	-	-	-	-	3

Mapping of CO (Course Outcome) and PO (Programme Outcome)
Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 615 Optimization Techniques 3-0-0 3 Credits 3 Hours*

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE615</td><td colspan="2">Optimization Techniques</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Engineering Mathematics, Discrete Mathematics</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: To understand the Basic principles of optimization.
CO2: To able to formulate optimization problem mathematically.
CO3: To know various solution methods in optimization Problems.
CO4: Able to perform sensitivity analysis and post processing of optimal solutions.
CO5: Able to explore a wide range of engineering optimization problems.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Introduction to Optimization- Development, mathematical problem formulation, engineering applications of optimization, classification of optimization problems. (3L)

Classical Optimization of Single and Multi variable- Optimality criterion for single and multi-variable method, Region elimination methods, Gradient based methods for single variable and Multivariable, unidirectional search, direct search methods. (10L)

Linear Programming- Standard form of linear programming (LP) problem, Graphical method, Simplex algorithm, Simplex criterion, Duality in LP, Sensitivity or post optimality analysis, Transportation Problem and Assignment Problem. (12L)
Dynamic Programming- Introduction, Sequential optimization, computational procedure, discrete versus continuous dynamic programming, curse of dimensionality. (3L)
Integer Programming- Introduction, Linear and Nonlinear integer programming, Methods for integer programming. (2L)
Non-Linear Programming- Introduction, examples of non-linear programming, types of non-linear programming, Constraint and Unconstrained optimization, methods of nonlinear programming. (7L)
Modern Optimization- Multi-objective optimization, many optimization, Genetic</td></tr>
</table>

	Algorithms, Particle Swarm Optimization, Differential Evolution, CMA-ES, applications in engineering optimization problems. (5L)
Text Books, and/or reference material	**Text Books:** 1. S. S. Rao, Engineering Optimization: Theory and Practice, New Age International. 2. K. Deb, Optimization for Engineering Design, Prentice Hall of India. 3. A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, Engineering Optimization: Methods and Applications, Wiley. 4. Hillier & Lieberman, Introduction to Operations Research, TMH. **Reference Books:** 1. S. M. Sinha, Mathematical Programming, Elsevier. 2. Handy Taha, Operations Research – An Introduction, Prentice Hall of India, New Delhi. 3. R. Fletcher, Practical Methods of Optimization, Wiley.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	-	-	-	-	-	2	3
CO2	2	3	2	3	1	-	-	-	-	-	3	3
CO3	3	3	3	2	1	-	-	-	-	-	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 616 Artificial Intelligence 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 616	Artificial Intelligence	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Data Structure and Algorithm, DBMS, Object Oriented Programming		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Learns Concepts of Intelligence, Artificial Intelligence, Problem Representation and Characterization. • CO2: Conceptualizes Intelligent Search, different heuristics. • CO3: Understands Knowledge Representation Techniques and Uncertainty Managements. • CO4: Learns Semantic Knowledge, Semantic Net and Frame. • CO5: Learns Game Playing Program Design.						

	• CO6: Learns Expert Systems and Various Machine Learning Systems. • CO7: Learns Neural Networks.
Topics Covered	Introduction to Artificial Intelligence (AI): Features of natural intelligence, Definition of Artificial Intelligence (AI), Turing Test. (4L) Problem Representation and Characterization: State Space Representation, Production Systems, Search, Problem Characterization. (5L) Intelligent Search Techniques: Search Classifications, Heuristic Function, Various Types of Heuristic Search Techniques, Performance Measure of Heuristic Search with Penetrance. (5L) Knowledge Representation Methodologies: Types of Knowledge, Propositional vs. Predicate Logic, Resolution Proof, Logic Programming, Knowledge representation using Rules, Declarative and Procedural Representation, Uncertainty Management in Knowledge Representation, Certainty Factors in facts and rules, Concept of Fuzzy Logic. (5L) Semantic Knowledge Representation: Syntactic vs. Semantic Knowledge, examples of Semantic Knowledge, Semantic Net, Frame, OOP, Property Inheritance, Tangled Hierarchies. (4L) Game Playing: Game Tree, Minimax Search, Search Reduction by alpha and beta cutoffs. Planning: Introduction to Planning, Goal Stack Planning, Nonlinear, Hierarchical and Reactive Planning. (4L) Learning: Learning and Intelligence, Learning Spectrum, Various Types of Learning Techniques and Systems. (5L) Expert Systems (ES) and ES Shells: Definition of Expert Systems, Components of Expert Systems. Types of ES – Manual, Semi-automatic, and Automatic ES, Techniques of Knowledge Acquisition (KA) for ES.-- ES Shell. Advantages and disadvantages of ES Shell over ES. (5L) Neural Networks: Symbolic vs. Neural Network AI, Hofield Network, Perceptron as a model of neuron, Single and multiplayer Perceptron for classification and knowledge representation, Back propagation Network, Supervised, Reinforcement and Unsupervised Learning. AI standardization: Needs for standardization, Data quality analysis standards, bias compliance standard, standardization efforts underISO/IEC/ CD 42000 series

	and ISO/IEC CD 5200X series. (5L)
Text Books, and/or reference material	**Text Books:** 1. Artificial Intelligence -- Rich and Knight. -- Tata McGraw Hill. 2. Artificial Intelligence – A New Synthesis – Nilsson. -- Morgan Kaufmann Publishers. **Reference Books:** 1. Artificial Intelligence and Expert Systems -- Paterson. -- PHI. 2. Artificial Neural Networks – B. Yegnanarayanana. PHI.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	-	-	-	-	-	3
CO2	3	3	2	2	2	-	-	-	-	-	-	3
CO3	3	2	2	3	2	-	-	-	-	-	-	3
CO4	3	2	2	3	2	-	-	-	-	-	-	3
CO5	3	3	3	3	2	-	-	-	-	-	-	3
CO6	3	3	3	3	2	-	-	-	-	-	-	3
CO7	3	2	3	3	2	-	-	-	-	-	-	3

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 617 Advanced Algorithms 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit	
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours		
CSE 617	Advanced Algorithms	PEL	3	0	0	3	3	
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))						
CSC 303, CSC 403		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**						
Course Outcomes	• CO1. Can have the efficiency in the complexity analysis of the algorithms. • CO2. Detecting and applying the algorithmic structures in many different fields of engineering. • CO3. Will have the knowledge for state of the art development in the field of algorithms. • CO4. Can have the proficiency of coding and comparing different algorithms.							
Topics Covered	**Revisit:** Different Complexity analysis and Algorithm's correctness by Loop-Invariant techniques.							

	(2L) **Data Structures:** van Emde Boas Trees, Dynamic graphs, Bloom filters, Hashing (Open addressing). (5L) **Randomized Algorithm-** Las Vegas and Monte Carlo algorithms, Essential mathematical tools for Randomized algorithms: Linearity of expectation, Markov inequality, Chebyshev's inequality, Chernoff bound, and Union bound with examples to Randomized algorithm design. Examples and analysis of: Hiring Assistant Problem, Randomized selection, Skip list. (4L) **Network Flow -** Flow networks, Augmenting paths, Ford- Fulkerson Algorithm, Edmonds - Karp algorithm, Max flow min-cut theorem, Push-relabel algorithm, Maximum bipartite matching, Some applications of network flow. (5L) **Linear Programming:** Introduction, algorithms, and its applications, Linear programming duality. (4L) **Parallel Algorithms** – Multithreaded Algorithms: Multithreaded matrix multiplication, Multithreaded merge sort. (3L) **Online Algorithms:** Overview, Online scheduling and online Steiner tree, Online Bipartite matching,Online learning and multiplicative weights algorithm. (5L) **NP- Completeness** - Reduction revisited; NP-Completeness proof of different problems: CLIQUE, VERTEX COVER, INDEPENDENT SET, SET COVER. (4L) **Approximation Algorithms** - Constant factor approximation algorithm: VERTEX COVER and TSP; Christofides algorithm on TSP with 1.5 approximation factor; SET-COVER problem with log n factor approximation algorithm; PTAS and FPTAS, Linear programs and approximation algorithms. (7L) **Semidefinite Programming:** Introduction with the problem: The Maximum Cut Problem and Semidefinite Programming. (2L) **Overview of some Special Topics:** Communication complexity, Spectral graph theory, Compressive sensing . (1L)

Text Books, and/or reference material	**Text Books:** 1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, 2nd Edition, Cambridge University press, Cambridge, MA, 1995. 2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009, ISBN: 9780262033848. 3. S. G. Akl, The Design and Analysis of Parallel Algorithms, Prentice-Hall, 1989. 4. M. J. Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw Hill Higher Education, 1987, ISBN: 978-0070510715. 5. J. Kleinberg and E. Tardos, Algorithm Design, Pearson. 6. D. V. Williamson and D. B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press. 7. S. Arora and B. barak, Computational Complexity: A Modern Approach, Cambridge University Press. **Reference Books:** 1. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, July 2008. 2. M. Mitzenmacher and E. Upfal, Probability and Compuitng: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press. 3. T. Roughgarden, CS261: A Second Course in Algorithms (Stanford University), 2016. 4. T. Roughgarden, CS168: Modern Algorithmic Toolbox (Stanford University), 2017. **Others:** *NMEICT video on:* *Design of Algorithms(http://www.nmeict.iitkgp.ac.in/Home/videoLink/10/3gp)*

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	1	2	2	-	-	-	2	2
CO2	3	2	3	3	2	2	2	1	1	1	2	2
CO3	3	2	3	3	2	2	2	1	-	1	2	3
CO4	2	2	3	3	3	2	2	2	2	2	2	2

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 618 Information Coding Theory 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 618	Information	PEL	3	0	0	3	3

	coding theory						

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Probability and statistics, linear algebra, calculus.	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	• CO1: Understanding definition and measurement of information. • CO2: Understanding source coding and Design and analysis of data compression techniques. • CO3: Understanding Channel coding theory • CO4: Design and analysis of Error correction coding
Topics Covered	Introduction, Mathematical Measure of Information, Average and Mutual Information and Entropy, Properties of Entropy, Discrete memoryless sources (DMS), Extension of DMS, Markov sources, Source coding theorem, Fixed length and variable length coding, Kraft inequality, Properties of prefix codes. (8L) Source Coding: Lossless entropy encoding, Huffman code, Huffman code applied on the symbols of extended sources, Shannon-Fano coding, efficiency calculations, Lempel-Ziv codes, arithmetic coding, Rate distortion Theory. (8L) Lossless and lossy predictive coding and decoding, Quantization, PCM, DM, ADM, DPCM. (6L) Channels and Channel Capacity: Discrete memoryless channel model, Binary symmetric channels and channel capacity, entropy rate and channel coding theorem, information capacity theorem. (6L) Error correction codes: Introduction, Basic concepts of linear algebra including group, ring, field, vector space etc. (3L) Block codes: Introduction, single parity check codes, product codes, repetition codes. (3L) Linear Codes: Definition, encoding and decoding of linear codes, generator matrix, error detection and correction, Perfect codes, Hamming codes. (5L) Cyclic codes: Definition, polynomials, encoding and decoding techniques, cyclic redundancy check. (3L)
Text Books, and/or reference material	**Text Books:** 1. Information Theory and Coding Hardcover by Norman Abramson, McGraw-Hill. 2. Elements of Information Theory (Wiley Series in Telecommunications and Signal Processing) by Thomas M. Cover, Joy A. Thomas, Wiley-Blackwell. 3. Error Control Coding by Shu Lin, Daniel J. Costello, Pearson. **Reference Books:** 1. Coding and Information Theory by Steven Roman, Springer-Verlag. 2. Error Control Coding by Peter Sweeney, John Wiley & Sons.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	-	-	-	-	-	-	-	3
CO2	2	3	3	2	-	-	-	-	-	-	-	3
CO3	3	3	3	2	-	-	-	-	-	-	-	3
CO4	2	3	3	2	-	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 619 Computer Graphics 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE619</td><td colspan="2">Computer Graphics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Introduction to Computing</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">After completing the course, the students will be able to:
● CO1: Understand Graphics Hardware, Software.
● CO2: Learn various 2D algorithms and 3D algorithms.
● CO3: Learn and analyze scan conversion - lines, circles, ellipses, filling polygons, clipping algorithms, solid modeling, visible surface algorithms.
● CO4: Learn Illumination and Shading Models, Plane Curves and Surfaces.
● CO5: Apply different algorithms to solve real life problems.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Section 1 Introduction to Computer Graphics, Graphics Application and Software, Description of some graphics devices, Active and Passive Graphics Devices, Display Technologies, LCD displays. (6L)
Section 2 Two-Dimensional Transformations and Matrices, Transformation Conventions, 2D Transformations, Rotation, Reflection, Scaling. (6L)
Section 3 Three-Dimensional Transformations Introduction, Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation, Three-Dimensional Reflection, Three-Dimensional Translation. (6L)
Section 4 Filling polygons and clipping algorithms, Clipping Lines algorithms–Cyrus-Beck, Cohen-Sutherland and LiangBarsky, Clipping Polygons. (6L)
Section 5 Visible-Surface Determination Techniques, Categories of algorithms, Back face removal, The z-Buffer Algorithm, Scan-line method, Painter’s algorithms (depth sorting), Area sub-division method, BSP trees. (6L)
Section 6 Illumination and Shading Illumination and Shading Models for Polygons, Reflectance properties of surfaces, Ambient, Specular, and Diffuse reflections, Atmospheric attenutation, Phong’s model, Gouraud shading, some examples. (6L)
Section 7 Plane Curves and Surfaces Curve Representation, Parametric Representation of a Circle, Ellipse, Parabola, Hyperbola, Space Curves, Cubic</td></tr>
</table>

	Splines, Bezier Curves, B-spline Curves, B-spline Curve Fit, B-spline Curve Subdivision. (6L)
Text Books, and/or reference material	**Text Books:** 1) J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, Computer Graphics - Principles and Practice, Second Edition in C, Pearson Education, 2003. 2) D. F. Rogers and J. A. Adams, Mathematical Elements for Computer Graphics, 2nd Edition, McGraw-Hill International Edition, 1990. **Reference Books:** 1) D. Hearn and M. Pauline Baker, Computer Graphics (C Version), Pearson Education, 2nd Edition, 2004. 2) F. S. Hill Jr., Computer Graphics using OpenGL, Pearson Education, 2003. **Others:** NPTEL Course: https://nptel.ac.in/courses/106106090/

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	-	-	-	-	-	1	2
CO2	3	2	3	3	1	-	-	-	-	-	1	2
CO3	3	3	3	3	3	1	-	-	-	-	1	2
CO4	3	2	3	3	2	1	-	-	-	-	1	2
CO5	3	2	3	3	3	1	-	1	2	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 620 Game Theory and its Applications 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 620	Game Theory and its Applications	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))
1. MAC 01: Mathematics - I 2. MAC 02: Mathematics - II 3. MAC 331 : MAC 01: Mathematics - III	CT: 15%, MT: 25%, EA: 60%

Course Outcomes	After completion of this course, the students: • CO1: Can have the efficiency to remember concepts to act in a strategic situation. • CO2: Can analyse the strategic interactions among agents. • CO3: Can understand modern state of the art in Game Theory. • CO4: Will have the knowledge of related area where Game Theory can be

	applied.
Topics Covered	**Introduction:** Motivation to the course. (2L) **Non-Coperative Game Theory:** Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominat Strategy Equllibria, Pure Strategy Nash Equlibrium, Mixed Strategy Nash Equlibrium, Fixed Point Theorem and Existence of Nash Equillibrium, Computation of Nash Equillibrium, Complexity of Computing Nash Equillibrium, Matrix Games (Two Players Zero sum Games), Bayesian Games, Subgame Perfect Equlibrium. (10L) **Mechanism Design without Money**: One sided and two sided matching with strict preferences, Voting theory, and Participatory democracy. (4L) **Mechanism Design with Money:** Auction basics, sponsored search auctions, Revenue optimal auctions, VCG Mechanisms. (5L) **Cooperative Game Theory**: Correlated Strategies and Correlated Equilibrium, Two Person Bargaining Problem, Coalitional Games, The Core, and The Shapley Value. (5L) **Repeated Games:** Introduction to repeated games and its Applications. (4L) **Applications:** Incentive Study in - P2P Networks, Crowdsourcing, Digital currency. (5L) **Some Special Topics**: Fair Division, Price of Anarchy, Scoring rules, Learning in Auction, Synergies between Machine Learning & Game Theory. (7L)
Text Books, and/or reference material	**Text Books:** 1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829. 2. M. Maschler, E. Solan, and S. Zamir. Game Theory, Cambridge University Press; 1st Edition, ISSN: 978-1107005488, 2013. 3. Y. Narahari. Game Theory and Mechanism Design. World Scientific Publishing Company Pte. Limited, 2014, ISSN: 978-9814525046. 4. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791. **Reference Books:** 1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013. 2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016. 3. S. Barman and Y. Narahari, E1:254 Game Theory Course (IISc Bangalore), 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	2	2	3	2	1	-	-	-	-	-	1	2
CO2	2	3	3	3	2	1	-	-	-	-	1	2
CO3	3	2	3	3	2	1	-	-	-	-	1	3
CO4	3	2	3	3	3	1	1	1	2	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 621 Digital Systems Testing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE621	Digital Systems Testing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Logic Design, Computer Organisation		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: To explain and exemplify basic and advanced concepts of Testing of Digital Circuits. • CO2: To understand fault modeling and test generation. • CO3 : To fully appreciate the need for testability measures in the design stage of circuits. • CO4: To understand the use of built in testing measures for online testing. • CO5: To appreciate the different testing strategies for memory based devices.						
Topics Covered	Introduction to VLSI testing and verification. Logic and Event Driven Simulation. (2L) Fault Modeling. Single Stuck-at Fault model. Fault Collapsing. Fault Equivalence. Fault Domination. Checkpoint Theorem. (8L) Fault Simulation. Serial, Parallel, Deductive and Concurrent. (3L) Test Generation. Boolean Difference Method. D-Algorithm. PODEM. FAN. (8L) Testability Analysis (3L) Design for Testability. Adhoc approaches. Scan based Design. Random Scan. Scan FF design. LSSD. Scan-Hold FF. (8L) Built-in Self Test. Pseudo-Random Pattern Generation. LFSR (8L) Memory testing. (2L)						
Text Books, and/or reference material	**Text Books:** 1. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers. 2. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications. **Reference Books:** **1.**VLSI Test Principles and Architectures. LT Wang et.al. Morgan Kaufman.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1	2	-	-	-	-	-
CO2	3	3	3	2	2	-	-	-	-	-	-	-
CO3	3	3	3	2	3	-	-	-	-	-	-	-
CO4	3	3	3	3	3	-	-	-	-	-	-	-
CO5	3	3	3	3	3	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 622 Soft Computing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 622	Soft Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Introduction to computing, Data Structures and Analysis of Algorithms		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: To familiarize with neural networks and learning methods for neural networks and its limitations. • CO2: To introduce basics of genetic algorithms and their applications in optimization and planning. • CO3: To introduce the ideas of fuzzy sets, fuzzy logic and fuzzy inference system. • CO4: To introduce students' tools and techniques of Soft Computing. • CO5: To develop skills thorough understanding of the theoretical and practical aspects of Soft Computing.						
Topics Covered	**Module I: Introduction** (6L) Introduction and different definitions of Soft Computing, Basic tools/members of Soft Computing: Fuzzy Logic, Neural Network and Evolutionary Computing. **Module II: Fuzzy Logic** (10L) **Fuzzy Logic-I:** Crisp Sets, Fuzzy sets, Fuzzy membership functions, Basic operations on fuzzy sets, Fuzzy relations and Composition of fuzzy relations. **Fuzzy Logic –II (Fuzzy Rules and Approximate Reasoning):** Fuzzy if-then rules: M-A and TSK Rules, Fuzzification, Compositional rule of Inference/Approximate Reasoning, Defuzzification, Applications: Pattern Recognition, Fuzzy c-means Clustering and Control. **Module III: Neural Networks** (10L) **Neural Networks-1 (Introduction & Architecture):** Introduction to neural						

	networks: Artificial Neuron and its model, Activation functions, Neural network architecture, learning algorithms/rules, Training and testing. **Neural Networks-II:** Perceptron model: single layer and multilayer perceptron (MLP), Error back propagation, Radial basis function network (RBFN), Self-organizing map network (SOMN), Recurrent neural network, Applications of ANN. **Module IV: Evolutionary Computing** **(**12L**)** **Genetic Algorithm–I:** Evolutionary Computing, Basic concepts and working principle of simple GA (SGA), Genetic Operators: Selection, Crossover and Mutation, flow chart of SGA, Chromosome Encoding & Decoding, Population Initialization, Objective/fitness Function, variable length Chromosome, Applications: Travelling Salesman Problem (TSP). **Genetic Algorithm–II (Multi-objective Genetic Algorithm (MOGA)):** Conflicting objectives, Objective space and variable space, Domination, Pareto front, Pareto Set, NSGA-II: Non-dominated Sorting, Crowding distance operator, Applications. Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Local Search and Memetic algorithm. **Module V: Hybridization of different Soft Computing Tools** (4L)
Text Books, and/or reference material	**Text Books:** 1. S. Rajsekharanand and Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications", Prentice Hall of India. 2. N. P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press. 3. G. Klir and B. Yuan, "Fuzzy sets and Fuzzy logic", Prentice Hall of India. 4. K. H. Lee., "First Course on Fuzzy Theory and Applications", Springer-Verlag. 5. G. J. Klir and T. A. Folger: Fuzzy Sets, Uncertainty, and Information, PH. 6. J. Yen and R. Langari, "Fuzzy Logic, Intelligence, Control and Information", Pearson Education. 7. D. Goldberg: Introduction to Genetic Algorithm. **Reference Books:** 1. Siman Haykin, "Neural Networks", Prentice Hall of India. 2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley India. 3. Kumar Satish, "Neural Networks", Tata Mc. Graw Hill. 4. B. Yegnanarayana , "Artificial Neural Networks" 5. A. Konar, "Computational Intelligence", Springer. 6. Y. H. Pao: Adaptive Pattern Recognition and Neural Networks, Addison-Wesley.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	3	-	-	-	-	-	-	3

CO2	2	3	3	3	3	-	-	-	-	-	-	3
CO3	2	3	3	3	3	-	-	-	-	-	-	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3
CO5	3	3	3	3	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 623 Advanced Database Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 623	Advanced Database Systems	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Fundamentals of DBMS, Data Structures	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	• CO1: Acquire knowledge about the design and application view of DBMS. • CO2: Able to analyze query expression, specially importance of query optimization. • CO3: To learn about design, features and operations in the field of DDBMS, OODBMS and DW. • CO4: To learn the concept of multimedia database as a real-life application.
Topics Covered	**Unit-1:** Comparison between different databases: Significance of Databases, Database System Applications, Advantages and Disadvantages of different Database Management systems, Comparison between DBMS, RDBMS, Distributed and Centralized DB, Introduction of various types of index structures: Primary, Secondary, Multilevel, Dynamic multilevel (B-tree and B+- tree). (3L) **Unit-2:** Normalization: Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form, The boyce-code normal form(BCNF), Fourth Normal form and fifth normal form, normalization and database design, Denormalization, Lossless join decomposition, Dependency preservation. (3L)

	Unit-3: Transaction processing: Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability, Transaction management in multi-database system, long duration transaction, high-performance transaction system. (3L) **Unit-4:** Concurrency Control Serializability: Enforcing, Serializability by Locks, Locking Systems With Several, Lock Modes, Architecture for a Locking Scheduler Managing Hierarchies of Database Elements, Concurrency Control by Timestamps, Concurrency Control by Validation, Database recovery management. (3L) **Unit-5:** Query Optimization: Algorithm for Executing Query Operations: External sorting, Select operation, Join operation, PROJECT and set operation, Aggregate operations, Outer join, Heuristics in Query Optimization, Semantic Query Optimization, Converting Query Tree to Query Evaluation Plan, multi-query optimization and application, Efficient and extensible algorithms for multi-query optimization. (5L) **Unit-6:** Query Execution: Introduction to Physical-Query-Plan Operators, One-Pass Algorithms for Database, Operations, Nested-Loop Joins, Two-Pass Algorithms Based on Sorting, Two-Pass, Algorithms Based on Hashing, Index-Based Algorithms, Buffer Management, Parallel Algorithms for Relational Operations, Using Heuristics in Query Optimization, Basic Algorithms for Executing Query Operations. (5L) **Unit-7:** Distributed Database (DDB): Introduction of DDB, DDBMS architectures, Homogeneous and Heterogeneous databases, Distributed data storage, Advantages of Data Distribution, Disadvantages of Data Distribution Distributed transactions, Commit protocols, Availability, Concurrency control & recovery in distributed databases, Directory systems, Data Replication, Data Fragmentation. Distributed database transparency features, distribution transparency. (5L) **Unit–8:** Object Oriented DBMS(OODBMS): Overview of object: oriented paradigm, OODBMS architectural approaches, Object identity, procedures and encapsulation, Object oriented data model: relationship ,identifiers, Basic OODBMS terminology, Inheritance , Basic interface and class structure, Type hierarchies and inheritance, Type extents and persistent programming languages, OODBMS storage issues. (5L) **Unit –9:** XML Query processing: XML query languages: XML-QL, Lorel, Quilt, XQL, XQuery, and Approaches for XML query processing, Query processing on relational structure and storage schema, XML database management system. (4L) **Unit –10:** Data Warehousing: Overview of DW, Multidimensional Data Model, Dimension Modelling, OLAP Operations, Warehouse Schema (Star Schema, Snowflake Schema), Data Warehousing Architecture, Virtual Data, Metadata and Types of Metadata, OLAP Engine, Data Extraction, Data Cleaning, Loading, Refreshing. (4L) **Unit-11:** Database application: Multimedia database, Video database management: storage management for video, video preprocessing for

	content representation and indexing. (2L)
Text Books, and/or reference material	**Text Books:** 1. "An Introduction to Data Base Systems", C. J Date, Pearson Education. 2. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 3. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:** 1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	1	1	1	1	1	2	2
CO2	2	2	3	2	2	1	1	1	1	1	2	2
CO3	2	2	3	2	2	1	1	1	2	1	2	2
CO4	2	3	3	2	1	1	1	1	1	1	1	2

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

MSC731 PRINCIPLES OF MANAGEMENT 3-0-0 3 Credits 3 Hours

<table>
<tr><td colspan="9">DEPARTMENT OF MANAGEMENT STUDIES</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MSC-731</td><td>PRINCIPLES OF MANAGEMENT</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Prerequisites- NIL</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1:To make budding engineers aware of various management functions required for any organization
• CO2:To impart knowledge on various tools and techniques applied by the executives of an organization
• CO3:To make potential engineers aware of managerial function so that it would help for their professional career
• CO4:To impart knowledge on organizational activities operational and strategic both in nature
• C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT I: Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter’s five forces, Management functions – overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization (8)
UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7)
UNIT III: Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8)
UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8)
UNIT V: Finance and Accounting: Basics of Financial management of an organization, Preparation of Financial accounting, Analysis of Financial statements, CVP Analysis, An overview of financial market with special reference to India .(12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House.
2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India
3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education
4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice</td></tr>
</table>

	hall India 5. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 751 Software Engineering Laboratory 0-0-3 1.5 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 751	Software Engineering Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	• CO1: Understand Control Flow Graph (CFG) and CFG based Functional Complexity of the software. • CO2: Understand the Coverage Criteria (Statement, Branch, Decision). • CO3: Software modelling through ERD, DFD and ERD for distinct cases. • CO4: Unified Modelling Language based system Design and code Generation. • CO5: Understand the basic concepts of Testing and Verification (Decision tree & graph, WBT, BBT, Unit testing).						
Topics Covered	1) Control Flow Graph based problems (Tool: C++/Java Language Compiler). 2) ERD / DFD related problems (Tool: StarUML ER Extension or Other OpenSource Tools). 3) UML based Design problems (Tool: Rational Rose/StarUML). 4) Software Testing related Problems (Tool: Junit) - Implementation Program on Java and testing using Junit. Suggested List of Applications:1. Student Marks Analysing System, 2. online Ticket Reservation System, 3. Payroll System, 4. Course Registration System, 5. Expert Systems, 6. ATM Systems, 7. Stock						

	Maintenance.
Text Books, and/or reference material	**References:** 1. Frances E. Allen, "Control flow analysis", Proceedings of a symposium on Compiler optimization archive, ACM SIGPlan Notices, Pages 1 – 19, 1970 2. Unified Modelling Language, Object Management Group, http://www.omg.org/spec/UML/ 3. JUnit User Guide, https://junit.org/junit5/docs/current/user-guide/

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	1	1	1	-	-	1	1
CO2	2	3	3	3	2	1	1	1	-	-	1	2
CO3	2	3	3	3	2	1	1	1	-	-	1	2
CO4	2	3	3	3	2	1	1	1	-	-	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSS 752 Modeling and Simulation Laboratory 0-1-3 2.5 Credits 4 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS 752	Modeling and Simulation Laboratory	PCR	0	1	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
		CT+EA [CT: 60%, EA(Laboratory assignment + Viva Voce): 40%]					
Course Outcomes	• CO1: Demonstrate the characteristics of mathematical modelling and Python packages. • CO2: Understand the concepts of mathematical modelling for a problem. • CO3: Understand the user-friendly editor of Python and various libraries for simulation of the problems. • CO4: Developed and implement the mathematical problems using Python.						
Topics Covered	1. Study the basic concepts of mathematical formulation for a problem. 2. Study the characteristics and packages of Python programming language. 3. Modeling and simulation of linear programming problems. a) Graphical Method b) Simplex Method 4. Modelling and simulation of Transportation problem. a) Different initialization solution techniques b) Balanced and Unbalanced						

	c) Degenerate problem 5. Modelling and simulation of Assignment problem. 6. Modelling and simulation of travelling salesman problem. 7. Modelling and simulation of network flow problem. 8. Modelling and simulation to find the dual of a primal problem. 9. Modelling and simulation to determine optimal strategy for a two person zero game. a) Pure Strategy b) Mixed strategy
Text Books, and/or reference material	**Text Books:** **1.** Rardin, Optimization in Operation Research, Pearson Publications. **2.** Handy A Taha, Operations Research – An Introduction, Prentice Hall of India, New Delhi. **3.** Hillier & Lieberman, Introduction to Operations Research, TMH.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	3	3	1	1	1	2	1	2	2
CO2	2	3	3	2	1	1	1	1	2	1	2	3
CO3	3	3	3	2	3	1	1	1	1	1	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Depth Elective – 3, 4, 5

CSE 710 Machine Learning 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 710	Machine Learning	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Probability and Statistics, Artificial Intelligence		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding of the basic concepts, fundamental issues and challenges of machine learning. • CO2: Comprehend the principle and techniques of supervised learning. • CO3: Explain the basic concepts and techniques of unsupervised learning. • CO4: Understanding of the basic concepts and challenges of reinforced learning. • CO5: Ability to apply the concepts of machine learning in different domains.						
Topics Covered	1. Introduction: what is Machine Learning; Human learning and Machine learning; Well-posed learning problem; Types of Machine Learning: Supervised, Unsupervised, and Reinforcement learning; Applications,						

	Issues, and tools of Machine Learning. (3L) 2. Concept Learning: Inductive learning hypothesis, general to specific ordering of hypothesis; FIND-S algorithm; Version space, candidate elimination algorithm; Inductive bias. (4L) 3. Bayesian Learning, Naïve Bayes Classifier, Optimal Classifier. (3L) 4. Supervised learning: Classification- k-Nearest Neighbour, Decision Tree, Support vector machine. Regression- Simple and Multiple linear regression. (9L) 5. Artificial Neural Networks: Biological neuron and artificial neuron, How ANN works, Parallel distributed model of ANN; Activation functions; Perceptron, McCulloch-Pits model, ADALINE network model; Architecture of ANN- single-layer feed forward, multi-layer feed forward, competitive network, recurrent network; Backpropagation algorithm; Basic concept of deep learning. (9L) 6. Unsupervised learning and Clustering: Different clustering techniques- Partitioning methods (k-means, k-medoid), Hierarchical methods (Agglomerative and Divisive techniques, MIN, MAX, Group average, Ward's methods) and Density-based method (DBSCAN). (5L) 7. Dimensionality Reduction: principal component analysis, singular value decomposition, Linear discriminant analysis, Independent conponent analysis, stochastic neighbour embeddingy. (6L) 8. Reinforcement Learning: Basic concept, Model based learning, Temporal difference based learning. (3L)
Text Books, and/or reference material	**Text Books:** 1.Machine Learning by Tom Mitchell [Mc. Graw-Hill]. 2. Pattern Recognition and Machine Learning by Christopher M bishop, Springer. 3.Applied machine Learning by M. Gopal [Mc. Graw-Hill, 2018] 4.NPTEL Course materials. **Reference Books:** 1. Introduction to Machine Learning by Ethem Alpaydin [MIT Press].

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	2	2	1	2	2	3	3
CO2	2	2	3	3	3	2	2	1	2	2	3	3
CO3	2	2	3	3	3	2	2	1	2	2	3	3
CO4	2	2	3	3	3	2	2	1	2	2	3	3
CO5	3	3	3	3	3	1	2	1	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 711 Graph Theory 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering				
Course	Title of the course	Program Core	Total Number of contact hours	Cred

Code		(PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	it
CSE 711	Graph Theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Discrete Mathematics and Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Understand the basic concept of graph and its properties. • CO2: Apply the basic properties of graph theory to prove different problems • CO3: Discuss chromatic characteristics and planar graphs. • CO4: Students can explore knowledge of graph theory to solve technology driven and research oriented problems. • CO5: Use a combination of theoretical knowledge and mathematical thinking to solve various computer science applications.
Topics Covered	**Preliminaries:** Graphs, isomorphism, automorphism, components, sub-graphs, degree, operations on graphs, radius, diameter, bipartite graph, Operations on graph: deletion of vertex/edge, fusion, union, intersection, ring sum, decomposition, join, Cartesian product, complement. Self-complementary graphs, circuits. (8L) **Connected graphs and shortest paths:** Walks, trails, paths, connected graphs, distance, cut-vertices, cut-edges, connectivity: edge and vertex connectivity, relationship between edge and vertex connectivity, k-connected graph, Menger's theorem, separable graph, blocks, block-cut vertex tree, block tree, cut vertex tree,1-isomorphism, 2-isomorphism, topological ordering. (8L) **Trees:** Characterizations, number of trees, minimum spanning trees, Distance between spanning tree of a connected graph, eccentricity, Centre(s) of trees and connected graph, diameter of tree and connected graph , nullity of tree, labelled graph. (3L) **Planarity:** Planar graph, Kuratowski's theorem , Euler's formula, Detection of planarity , duality, uniqueness of duality, Homomorphism: subdivision, merging, planarity detection using homeomorphism graphs, five color and four color problem. (5L) **Covering, Independent sets, Dominating Set, Matching:** Basic concepts, vertex and edge covering, minimal covering, independent set, maximal independent set, relationship between covering and independent set, theorems, dominating set, MDS, CDS, matching in bipartite graphs, perfect matching, maximal matching, minimum matching, Hall's theorem. (6L) **Factorization :** Factor, 1-factor, 2-factor Tutte's theorem. (3L)

	Vertex coloring: Chromatic number and cliques, greedy coloring algorithm, Brook's theorem, chromatic partition, Uniquely colourable graph. (3L) **Edge coloring:** Gupta-Vizing theorem, color edge, equitable edge-coloring. (2L) **Line Graph:** Properties and proof. (2L) **Eulerian graphs:** Characterization, Arbitrarily traceable graph, Fleury's algorithm. (2L)
Text Books, and/or reference material	**Text Books:** 1. Douglas B. West. Introduction to Graph Theory. Pearson Education, Second Edition. 2. R. Deistel. Graph Theory. Springer- Verlag NewYork 1997. 3. R.J. Wilson and J.J. Watkins. Graphs : An Introductory Approach. John Wiley and Sons Inc. **Reference Books:** 1. N. Deo. Graph Theory; With Applications to Engineering and Computer Science. PHI. 2. S. Pirzada. An Introduction to Graph Theory. Orient Blackswan.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	-	2	-	-	-	-	-	-
CO2	2	2	3	2	2	-	2	-	-	-	-	-
CO3	2	2	2	2	-	-	-	-	-	-	-	-
CO4	2	3	3	3	3	3	3	-	-	-	-	2
CO5	2	3	3	3	3	3	3	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 712 Electronic Design Automation 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE712	Electronic Design Automation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Electronics, Computer		CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]					

Organisation, Algorithm Analysis and Design.	
Course Outcomes	• CO1: To visit the various stages of the VLSI design cycle and appreciate the role of automation therein. • CO2: To appreciate how High Level Synthesis converts an HDL code into an architecture level design. • CO3: To discuss the algorithmic approach to physical design. • CO4: To emphasize the importance to testability measures in the design.
Topics Covered	VLSI Design cycle. Design styles. System packaging styles. Fabrication of VLSI devices. Design rules-overview. (3L) HLS: Scheduling in High Level Synthesis. ASAP and ALAP schedules. Time constrained and Resource constrained scheduling. (4L) HLS: Allocation and Binding. Datapath Architectures and Allocation tasks. (4L) Partitioning. Clustering techniques. Group Migration algorithms. (4L) Floorplanning. Constraint based Floorplanning. Rectangular Dualization. Hierarchical Tree based methods. Simulated Evolution approaches. Timing Driven floorplanning. (5L) Placement. Simulation based placement algorithms. Partitioning based placement algorithms. Cluster Growth. (5L) Global Routing. Maze Routing algorithms. Line probe algorithms. Shortest Path based algorithms. Steiner's Tree based algorithms. (5L) Detailed Routing. Channel Routing Algorithms. Switchbox Routing. Over-the-cell routing. Clock and Power Routing. (4L) Design for testability. Fault testing. Ad-hoc and structured DFT techniques. (8L)
Text Books, and/or reference material	**Text Books:** 1. Algorithms for VLSI Physical Design Automation. N.A.Sherwani. Kluwer Academic Publishers. 2. High-Level Synthesis: Introduction to Chip and System Design. Gajski et. al. . Kluwer Academic Publishers. 3. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications. **Reference Books** 1. VLSI Physical Design Automation. Sadiq M. Sait and Habib Youssef. Kluwer Academic Publishers. 2. Algorithms for VLSI Design Automation. Sabih H. Gerez. Wiley India. 3. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	3	2	1	-	-	-	2	-

CO2	3	3	3	3	3	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-
CO4	3	3	3	3	2	-	2	-	-	-	1	-

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 713 Natural Language Processing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 713	Natural Language Processing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
1. Basics of probability and statistics 2. CSC303: Data Structures and Algorithms 3. CSC 01: Introduction to Computing		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Describe the fundamental concepts underlying natural language processing (NLP). • CO2: Demonstrate the approaches to syntactic and semantic analysis in NLP. • CO3: Apply the concepts of NLP to solve real-life problems. • CO4: Analyze various solutions to an NLP problem and choose the best one.						
Topics Covered	Introduction to natural language processing. (1L) Basic Text Processing: Tokenization, Stemming. (2L) Minimum Edit Distance. (2L) Language Modeling: Introduction to N-grams, Estimating N-grams probabilities. Application of language modeling to real-life examples (such as text -classification). (4L) Generative Vs. Discriminative Models. (4L) POS Tagging. (4L) Parsing: Introduction of Probabilistic Parsing, Lexicalized Parsing, Dependency Parsing. (6L) Information Retrieval. (3L) Semantics: Word meaning and Senses. (3L) Machine Translation (rule based techniques, Statistical Machine Translation						

	(SMT), parameter learning in SMT (IBM models)). (4L) Two applications: Question Answering and Text Summarization. (4L) Recent trends. (3L) Standards for Indian Languages: Key layout - IS 16350 : 2016, inscript information IS 13194:1991 (2L).
Text Books, and/or reference material	**Text Books:** Jurafsky, David, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Prentice-Hall, 2000. ISBN: 0130950696. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. **Reference Books:** Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing. Cambridge, MA: MIT Press, 1999. ISBN: 0262133601. **Others:** 1. CS124: YouTube lecture videos by Dan Jurafsky. 2. 2012 NLP MOOC by Dan Jurafsky with Chris Manning:Youtube channel lecture videos

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	1	-	-	-	-	-	1
CO2	3	3	3	3	2	1	-	-	-	-	-	1
CO3	3	3	3	3	3	2	-	1	1	1	2	2
CO4	3	3	3	3	3	2	1	2	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 714 Data Warehousing and Data Mining 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 714	Data Warehousing and Data Mining	PEL	3	0	0	3	3
Pre-requisites Artificial Intelligence, DBMS, Object Oriented Programming		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					

	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	● CO1: Understanding the Concept of Data Warehousing and Data Mining. ● CO2: Association Rules: Item set, Support, Confidence. ● CO3: Classification – Pattern: Labelled Pattern, Decision Trees. ● CO4: To understand the SVM, Generalization Error. ● CO5: To understand the different types of Clustering Methods. ● CO6: To understand the detection of different types of outliers and outlier detection.
Topics Covered	Data Warehousing: Multidimensional Data Model, Dimension Modelling, OLAP Operations, Slicing and Dicing, Warehouse Schema, Star Schema, Snowflake Schema, Advantages and Disadvantages of Snowflake Schema, Data Warehousing Architecture, Virtual Data Warehouse, Advantages and Disadvantages of Virtual Data Warehouse, Metadata, Types of Metadata, OLAP Engine, Different Options for OLAP Engine, Data Extraction, Data Cleaning, Loading, Refreshing. [4L] Data Mining: Different Definitions of Data Mining, KDD vs. Data Mining, Stages of KDD , DBMS vs. DM, AI vs. DM, Classifications of Data Mining, Stages of KDD, DM Techniques , Discovery Driven Tasks, Classification, Frequent Episodes, Discovery of Association Rules , Clustering, Deviation Detection, Mining Problems, Applications of DM, Other Mining Problems. [4L] Association Rules: Item set, Support, Confidence, Problem Decomposition, Frequent Item Set, Maximal Frequent Set, Border Set, Applications of Data Mining, Spotting Fraudulent Behaviour, Astronomy etc., Association Rules, Informal a priori Algorithm for Learning Association Rules, Finding Frequent Sets and Association Rules, Formal a priori Algorithm for Association Rule. [5L] Classification – Pattern: Labelled Pattern, Approaches of Classification, Evaluation of Classifiers, Normalized Confusion Matrix, Accuracy, Precision, Recall and F – score, Cross Validation Technique, Classification Techniques. [4L] Decision Trees: Inductive Learning, ID3 Program, Algorithm for Building Decision Trees , Advantages of Decision Trees for Classification Purpose, Development of Decision Trees for Different Training Data Sets, Rule Extraction from Pattern Set, Covering the instances, Extraction of rules, Instance Space, Covering Algorithm. [4L] Bayesian Belief Nets (DAG): K nearest Neighbour, ANN, Learning in ANN, Perceptron as a model of neuron, Single and multiplayer Perceptron for classification and knowledge representation, Back propagation Network, Supervised, Reinforcement and Unsupervised Learning. [4L] Classification (Complex): Support Vector Machine (SVM), Generalization Error, SVM to find out the best classification, Margin. [3L] Clustering: Partitioned and Hierarchical Clustering, k means Clustering, Fast k Means Clustering, Fuzzy K means Clustering, Hierarchical Clustering,

	Agglomerative and Divisive Hierarchical Clustering, Single Linkage, Complete Linkage and Average Linkage Clustering. [4L] Clustering (Complex): Outlier Detection, Outlier vs. Cluster, Types of Outliers, Outlier Detection Methodologies, Supervised, Unsupervised and Semi supervised detection , Statistical Approaches, Parametric and Non Parametric Methods, Proximity Based Methods, Clustering Based Methods. [4L] Temporal and Spatial Data Mining: Temporal Data Mining, Tasks involved, Temporal Association Rules, Sequence Mining, Episode Discovery, Spatial Mining, Tasks involved , Spatial Clustering. [3] Web Mining: Web Mining Techniques, Web Content Mining, Web Structure Mining, Web Usage Mining, Text Mining. [3L]
Text Books, and/or reference material	**Text Books:** 1. Data Mining Techniques – Arun K Pujari – Universities Press. 2. Data Mining – Vikram Pudi, P. Radha Krishna – Oxford University Press. **Reference Books:** 1. Data Mining – J. Han, M. Kamber, J. Pei -- Elesvier. 2. Data Mining – Hand, Mannila and Smith – PHI.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	2	2	-	-	-	-	-	-	3
CO2	2	1	1	2	2	-	-	-	-	-	-	3
CO3	3	3	2	3	3	-	-	-	-	-	-	3
CO4	3	3	2	3	3	-	-	-	-	-	-	3
CO5	3	3	3	3	3	-	-	-	-	-	-	3
CO6	3	3	3	3	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 715 Digital Image Processing 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 715	Digital Image Processing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
NIL		CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]					
Course	• CO1: Understand image acquisition and camera basics.						

Outcomes	• CO2: Apply image enhancement and filtering techniques to the spatial and frequency domain of images • CO3: Design edge detection and segmentation algorithms for object detection and recognition purpose • CO4: Understand color image processing • CO5: Develop image compression models. • CO6: Develop image processing algorithms using ImageJ and Python.
Topics Covered	Introduction, Image acquisition process, image sensors, camera basics. (4L) Transform functions, Histogram, spatial and frequency filtering. (10L) Redundancy, compression models, coding methods. (8L) Point, Line, edge detection, thresholding, region based segmentation. (6L) Color models, color image processing, segmentation and compression using colors. (8L) Introduction to Image Processing using ImageJ and Python, Image databases. (6L)
Text Books, and/or reference material	**Text Books:** 1.Digital Image Processing by Rafael C Gonzalez & Richard E Woods. 2.Fundamentals of Digital Image Processing by Anil K Jain. **Reference Books:** Digital Image Processing by William K Pratt. **Others:** NPTEL online course.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	-	1	-	-	-	-	-	2
CO2	3	3	3	3	-	-	-	-	-	-	-	3
CO3	3	3	3	3	-	-	-	-	-	-	-	3
CO4	2	2	2	2	-	-	-	-	-	-	-	3
CO5	3	3	3	3	-	-	-	-	-	-	-	3
CO6	2	2	3	3	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 716 Data Analytics 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 716	Data Analytics	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	• CO1: Classify the labelled dataset into different classes and group the unlabelled dataset into different clusters by uncovering hidden patterns and correlations among them.. • CO2: Model a problem into a graph database after absorbing and connecting a large volume of data and performing the analytical task over the graph. • CO3: Develop a recommendation system by predicting users' preferences based on similarity measures and evaluating its performance using the metrics such as Precision, recall, and F1-score. • CO4: Understand and set up the Hadoop framework, which will allow them to efficiently manage and process big data in a distributed computing environment.
Topics Covered	Introduction to Data Analytics, Types of Data Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, and Prescriptive Analytics. Use Cases, Issues and Challenges in Big Data Analytics. (4L) Fundamentals of Statistics: Population, Sample, Parameter, Statistic, Variable. Descriptive Statistics, Inferential Statistics. Basic Probability Theory: Random Experiment, Sample Space, Random Variables, Probability, Conditional Probability, Independence, Conditional Independence, Expectation, Variance, Probability Distribution, Joint Probability Distribution, Conditional Probability Distribution. (8L) Similarity Measures: Jaccard Similarity, Cosine Similarity, Adjusted Cosine Similarity. Missing Value Prediction Techniques: Mean Centering, Weighted Average, Z-Score. (6L) Basics of Complex Network: Scale-Free Networks, Small-World Phenomenon, Degree Distributions, Transitivity or Clustering. Centrality Measures: Degree Centrality, Betweenness Centrality, Closeness Centrality, Eigenvector Centrality, PageRank Centrality. Community Structure, Community Detection Algorithms: Girvan-Newman, Fast Greedy, Label Propagation, Clique Percolation Method. Community Quality Metrics: Modularity, NMI, Conductance. (10L) Introduction to Data Mining, Machine Learning Techniques: Least Square Regression, Decision-trees, SVM. Clustering Techniques: K-Means. (8L)

	Introduction to Hadoop Ecosystem – HDFS, Map-Reduce, PIG, HIVE, HBase, Mahout, Zookeeper, Flume, Sqoop, etc. (6L)
Text Books, and/or reference material	**Text Books:** 1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data – EMC Education Services – Wiley. 2. Machine Learning: Hands-On for Developers and Technical Professionals – Jason Bell – Wiley. **Reference Books:** 1. Networks: An Introduction – M. E. J. Newman – Oxford University Press. 2. Hadoop: The Definitive Guide – Tom White – O'Reilly.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	-	-	-	2	-	1	-	-
CO2	3	3	3	3	-	1	2	-	2	2	3	-
CO3	3	3	3	3	1	1	3	-	2	2	3	1
CO4	2	2	1	1	3	3	1	2	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 717 Biometrics 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 717	Biometrics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Mathematics – Knowledge and ability to use calculus, probability, and statistics are essential.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	● CO1: Understanding biometrics systems and its different characteristics. ● CO2: Implementation of different biometrics systems including face, fingerprint, iris, palm, signature, EEG, etc. ● CO3: Apply the concept of unimodal and multimodal paradigms in biometrics systems. ● CO4: Analyze different feature extraction and learning techniques for biometrics systems. ● CO5: Design and develop real life biometrics systems.						

Topics Covered	Biometrics Overview: Introduction, characteristics of biometric systems, biometric systems, biometric functionalities, biometrics system errors, design cycles of biometric systems, applications of biometric systems, security and privacy issues. [4L] Image Processing Techniques: What is image processing?, origin of image processing, fundamental steps in digital image processing, components of image processing system, image sensing and acquisition, image sampling and quantization, basic relationships between pixels. [6L] Filtering: Background, basic intensity transformation functions, histogram processing, fundamentals of spatial and frequency domain filtering, smoothing filters, sharpening filters, Discrete Fourier Transform, Fast Fourier Transform. [4L] Pattern Classification Techniques: Introduction, Bayesian decision theory, maximum likelihood and Bayesian parameter estimation, non-parametric techniques, linear discriminant functions, multilayer neural networks, non-metric methods. [6L] Fingerprint Recognition: Introduction, ridge pattern, fingerprint acquisition, feature extraction, matching, and fingerprint synthesis. [6L] Face Recognition: Introduction, image acquisition, face detection, feature extraction, matching and advanced topics. [6L] Iris Recognition: Introduction, iris recognition systems, image acquisition, iris segmentation, iris normalization, iris encoding and matching, iris quality and performance evaluation. [4L] Multi-modal Biometric Systems: Introduction, sources of multiple evidence, acquisition and processing architecture, fusion levels. [2L] Other Biometrics: Signature, hand shape, ear, palmprint, etc. [4L]
Text Books, and/or reference material	**Text Books:** ● Anil K. Jain, Arun Ross, and Karthik Nandakumar, Introduction to Biometrics, Springer, 2011. ● J. L. Wayman, Anil K. Jain, D. Maltoni, D. Maio, Biometric Systems: Technology, Design and Performance Evaluation, Springer, 2005. ● R. M. Bolle, J. Connell, S. Pankanti, N. K. Ratha, A. W. Senior, Guide to Biometrics, Springer, 2004. ● Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2^{nd}

	Edition, Wiley, 2000. ● R.C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson, 2009. **Reference Books:** ● D. R. Kisku, P. Gupta and M. Tistarelli, Multibiometrics Systems: Modern Perspectives to Identity Verification, LAMBERT Publishing, 2012. ● D. R. Kisku, P. Gupta and J. K. Sing, Advances in Biometrics for Secure Human Authentication and Recognition, CRC Press, Taylor & Francis, 2013. ● D. R. Kisku, P. Gupta and J. K. Sing, Design and Implementation of Healthcare Biometric Systems, IGI Global, 2019. ● M. Dawson, D. R. Kisku, P. Gupta, J. K. Sing and W. Li, Developing Next-Generation Countermeasures for Homeland Security Threat Prevention, IGI Global, 2016. **Others:** Online Biometrics Courses 1. https://nptel.ac.in/courses/106104119/ 2. https://www.mooc-list.com/tags/biometric

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	1	1	1	-	-	1	2
CO2	2	3	3	2	3	1	2	1	-	-	1	2
CO3	2	3	3	2	3	1	2	1	-	-	2	2
CO4	2	3	2	3	2	1	1	1	-	-	2	1
CO5	3	3	3	3	2	1	2	1	-	-	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 718 Cryptography and Network Security 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 718	Cryptography and Network Security	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSE 602 Basic knowledge of linear algebra, probability theory. Programming skills are desirable.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Introduce the basic mechanisms of Cryptography. • CO2: Notion of computationally hard problems and their applications. • CO3: Notion of trap-door and one-way functions and their applications. • CO4: The attack and crypto-analysis. • CO5: Ability to design secure protocols and their vulnerability analysis.
Topics Covered	1. Introduction, X.800 : Security architecture for Open Systems Interconnection, Attack, Adversarial Behavior. (2L) 2. Basic Number Theory, Field, Extension Field and applications. (5L) 3. Confidentiality, Symmetric and Asymmetric Encryption, Public key encryption mechanisms - RSA, ElGamal, Rabin's, Asymmetric Key Encryption - DES, AES. (10L) 4. Attacks- Passive attacks, Side channel Attacks, Factorizations and Index calculation methods, Countermeasures. (7L) 5. Implementational Issues - Fast Hardware for symmetric and Asymmetric key. (5L) 6. Pseudo-random number generation, Stream ciphers. (3L) 7. Message Integrity, Cryptographic hashing, Message Authenticity, Message Authentication code. (3L) 8. Entity Authentication, Digital signature, Nonrepudiation. (5L) 9. Secure protocol designing - SSL, PGP and TLS. (2L)
Text Books, and/or reference material	**Text Books:** 1. Handbook of Applied Cryptography, CRC Press (free ebook). 2. Douglas Robert Stinson, Maura Paterson, Cryptography: Theory and Practice. 3. O. Goldrich, Fundamentals of Cryptography: Basic Tools, Cambridge University Press. 4. N. Koblitz, A Course in Number Theory and Cryptography. 5. Abhijit Das, Key Cryptography: Theory and -C. E. Veni Madhavan, Public .Practice **Reference Books:** 1. M. Bellare and S. Goldwasser, Lecture Notes on Cryptography, 2001. **2.** Abhijit Das, Computational Number Theory, CRC Press. **Others:** 1. Janathan Knudsen, Java Cryptography, O'Relly Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	-	-	-	-	-	-	-	-	2
CO2	3	2	1	-	-	-	-	-	-	-	-	2
CO3	3	2	2	-	-	-	-	-	-	-	3	2
CO4	-	3	3	2	-	-	-	2	-	-	3	-
CO5	-	-	3	2	3	2	-	2	-	-	3	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 719 Multimedia Information Systems 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE 719</td><td>Multimedia Information Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Knowledge of data structures databases and compression techniques</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">•CO1: In depth understanding of media characteristics and resource requirement.
•CO2: Organizing multimedia content, physical storage and retrieval of multimedia data, Content-based Search and retrieval, creating and delivering networked and multimedia presentations, securing multimedia content and current research directions in this area.
•CO3: Understanding networking of multimedia data and how technology can help us access, deliver, browse, search, enrich and share multimedia content.
•CO4: Understanding of multimedia database storage and retrieval.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overview of multimedia system: Textual information codes (Morse, ASCII, EBCDIC), audio, video and graphics, RTF, TIFF, RIFF. (3L)
Video and Animation: Capturing Graphics and Images Computer Assisted Graphics and Image Processing; Reconstructing Images; Graphics and Image Output Options. Basics; Television Systems; Digitalization of Video Signals; Digital Television; Basic Concepts; Virtual Reality, Video signal representation, Computer Video Format, Computer- Based animation, Animation Languages, Methods of controlling Animation, Display of Animation, Transmission of Animation. (10L)
Information representation, media synchronisation, SAS factors, relative and absolute temporal specifications, networking delays, Skew, Jitter, end to end delay factors, latency time for stored and captured objects. (6L)
Data Compression: Storage Space requirement, Coding Requirements Source, Entropy Coding Lossy Sequential DCT- based Mode, Expanded Lossy DCT-based Mode, JPEG and MPEG. (8L)
Data transmission techniques like simplex, duplex, baseband vs. broadband, synchronous transmission vs. asynchronous transmission, synchronization parameters. (5L)
Content-based Search and retrieval, creating and delivering networked and multimedia presentations, storage, manipulation, and retrieval of multimedia data residing across global computer networks, multimedia databases, indexing, retrieval by similarity. (10L)</td></tr>
<tr><td>Text Books, and/or reference</td><td colspan="7">Text Books:
Multimedia Information Networking, Nalin K.Sharda, Prentice Hall India.
Multimedia: Computing, Communications and Applications, Ralf Steinmetz and</td></tr>
</table>

material	Klara Nahrstedt, Pearson Education Asia. Multimedia Communications, Applications, Networks, Protocols and Standards, Fred Halsall, Pearson Education Asia. Multimedia Systems, John F. Koegel Buford, Pearson Education Asia. **Reference Books:** Subrahmanian and Jajodia, Multimedia Database Systems, Springer. V.S. Subrahmanian, Principles of Multimedia Database Systems, Morgan Kaufmann Publishers, 1998.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	2	3	3	1	1	3	2	3
CO2	3	3	3	2	3	3	3	1	2	3	2	3
CO3	3	3	3	2	2	3	3	1	2	3	2	3
CO4	3	3	3	2	3	3	3	1	2	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 720 Cellular Automata and its Application 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE720	Cellular Automata and its Application	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Electronics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	● CO1: Understanding the basic and advanced concepts of Cellular Automata (CA). ● CO2: Understanding the different phases of evolution of CA machine. ● CO3: Understanding the method of characterization of CA machine/tool. ● CO4: Modeling of physical/real-time systems with a mathematical tool such as CA. ● CO5: Applying suitable class of CA for building CA based model to study.						
Topics Covered	**Introduction:** Basic definitions of cellular automata and symbolic dynamics, Injectivity, surjectivity, reversibility, Garden-of-Eden theorem, Hedlund's theorem, Conservation laws, universal computing reversible/irreversible CA, neighbourhood, dimensions, states, follow-up and review. [6L] **Characterization of CA behaviour and its applications:** Initial Phase of						

	Development, CA-Based Models - Language Recognizer, Biological Applications, CA as Parallel and Image Processing Systems, CA based model of physical systems. [6L] **New Phase of Development**–Wolfram's model of CA, 3-neighborhood 2-state CA, CA rules, Classification of rules, CA technology, CA as an FSM, Linear/non-linear/additive CA, Polynomial Algebraic Characterization of CA Behavior, Matrix Algebraic Characterization. [6L] **Irreversible/Group CA characterization in linear domain:** Null/Periodic boundary Characterization of the State-Transition Behavior, Cycle Set Characterization, Isomorphism between a CA and an LFSR. CA based Pseudorandom Pattern Generation, Pseudo noise sequence, CABIST, Pattern Classification. [6L] **Characterization of nongroup CA/non-invertible CA in linear domain**: General Characterization of Cyclic States (attractors), Characterization of Single Length Cycle Single Attractor CA (SACA), D1*CA, Multiple-Attractor Cellular Automata (MACA)[6L] **Non-linear CA:** Characterization of non-linear rules, invertible and non-invertible CA, CA with point states; applications in VLSI domain. [6L] **Advanced Concepts:** Extension of dimension, d-state CA, introduction to Asynchronous CA, follow-up and review**.** [6L]
Text Books, and/or reference material	**Text Books:** 1. Additive Cellular Automata: Theory and Applications, by Parimal Pal Chaudhuri, Dipanwita Roy Chowdhury, Sukumar Nandi, Santanu Chattopadhyay, Wiley. 2. Tommaso Toffoli, Norman Margolus. Cellular Automata Machines: A New Environment for Modelling. MIT Press. 3. *Cellular Automata and Complexity: Collected Papers* by Stephen Wolfram; Westview Press. **Reference Books:** 1. Game of Life Cellular Automata, by Andrew Adamatzky, Springer; 2010 edition. 2. A New Kind of Science, by Stephen Wolfram, Wolfram Media. 3. A New Kind of Computational Biology, by Chaudhuri, P.P., Ghosh, S., Dutta, A., Choudhury, S.P; Springer. 4. Joel L. Schife. Cellular Automata: A Discrete View of the World. Wiley - Interscience.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	-	1	-	-	-	-	1

CO2	1	1	1	1	1	-	1	-	-	-	-	1
CO3	1	2	1	1	2	-	1	-	-	-	-	1
CO4	3	3	3	3	3	-	2	-	-	-	-	3
CO5	3	3	3	3	3	-	2	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 721 Computational Geometry 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 721	Computational Geometry	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
A course on Design and analysis of algorithm		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: To demonstrate familiarity with some of the basic algorithmic techniques of the area. • CO2: To design and analyze "new" geometric algorithms and to derive the lower bound for some geometric problems. • CO3: To map practical problems to computational geometric problems and finding a solution to these geometric problems help to solve a wide range of practical problems in a variety of fields such as graphics, robotics, databases, sensor network • CO4: To develop skills to work on geometrical manipulating software and to demonstrate acquaintance with modern research in the field.						
Topics Covered	**Computational Geometry Introduction:** Historical perspectives, Geometric preliminaries, Convex Hull, Algorithms to find the Convex Hull of a point set in 2D plane: Graham's Scan Algorithm, Divide and Conquer algorithm, Output sensitive algorithm: Jarvis's March Algorithm, Timothy Chan's Algorithm; Lower bound analysis for Convex Hull Algorithm [6L] **Line Segment Intersection**: Line Segment Intersection, The Doubly-Connected Edge List, Computing the Overlay of Two Subdivisions, Boolean Operations. [4L] **Polygon Triangulation:** Guarding and Triangulations, Area of a simple polygon, Counting the number of triangulations in a convex polygon, Art Gallery Theorem, Monotone Polygon, Partitioning a Polygon into Monotone Pieces, Triangulating a Monotone Polygon.						

	[6L] **Orthogonal Range Searching:** 1-Dimensional Range Searching, Kd Trees, Range Trees, Higher-Dimensional Range Trees, Fractional Cascading. [6L] **Point Location:** Point Location and Trapezoidal Maps, A Randomized Incremental Algorithm to compute a Trapezoidal Map and a Search structure, Kirkpatrick's planar point location problem. [6L] **Voronoi Diagram and Delaunay Triangulation:** Definition and Basic Properties of Voronoi Diagram, Computing the Voronoi Diagram: Fortune Sweep Algorithm, Divide and Conquer Algorithm. Closest pair Problems. Application of voronoi diagrams, Triangulations of Planar Point Sets, The Delaunay Triangulation, Computing the Delaunay Triangulation. [7L] **Arrangements and Duality:** Arrangement of lines, Zone theorem, Duality, Application of arrangements and duality, Ham Sandwich Cut. [4L] **Geometric Data Structure:** Interval Trees, Priority Search Trees. [3L]
Text Books, and/or reference material	**Text Books:** 1. Franco P. Preparata and Michael Ian Shamos, Computational Geometry- An Introduction, Springer Verlag. 2. Mark de Berg, Marc van Kreveld, Mark Overmars, Otfried Cheong, Computational Geometry: Algorithms and Applications, Third Edition, Springer Verlag. 3. Joseph O' Rourke, Computational Geometry in C, Cambridge University Press. **Reference Books:** **Others:** Lecture notes on Computational geometry by David Mount.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3	3	2	-	-	-	-	-	-	2
CO2	1	2	3	3	2	-	-	-	-	-	-	2
CO3	1	2	3	3	3	-	-	-	-	-	-	2
CO4	1	2	3	3	3	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 722 Complex Network Theory 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hour	

						s	
CSE 722	Complex Network Theory	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Probability, Calculus, Linear Algebra, Graph Theory	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**
Course Outcomes	• CO1: Illustrate the modern theory and applications of network science. • CO2: Analyze structure of communities in different networks • CO3: Define random walk and design real-world applications • CO4: Apply of linear algebra and probability to real-world complex network problems • CO5: Cultivate reading of research papers and articles
Topics Covered	**Introduction to Network Science** (1L) **Graph Theory:** revision of basic concepts. (2L) **Properties of Complex networks**: Degree distribution, associativity, clustering coefficient.(4L) **Random Networks**: Poisson's distribution, giant component and its emergence, generating function, component size distribution. (6L) **Bipartite networks**: unipartite projection, giant component condition. (6L) **Centrality measures**: degree centrality, closeness centrality, betweenness centrality, eigen vector centrality, Peron Frobenius theorem.(4L) **Spectral Graph Theory**: eigen values and eigen vectors, spectrum of a graph, spectrum of a clique, eigen values and eigen vectors of special matrices like triangular and diagonal matrices, Markov matrix, trace of a matrix, physical interpretation of principal eigen vector, spectral coverage, significance of 2^{nd} eigen vector, Motifs, Frobenius norms, dimension reduction. (4L) **Network Models:** Erdos Renii graph, power law distribution in small world network, scale free networks. (4L) **Random walks on graphs and its applications:** random walks and Markov chain, transitional probability, stationery state, hitting time, commute time, cover time, mixing rate, stochastic matrix, page rank algorithm, page rank ++, HITS (Hypertext induced topic selection) algorithm by Klienberg, HITS on citation networks, bibliographic coupling, SALSA (The stochastic approach to Link Structure analysis and TKC effects). (7L) **Community detection algorithms:** what is a community, core community, Wu-Huberman Algorithm, Radicchi's Algorithm, community detection algorithms based on shortest path betweenness and random walk betweenness.(4L)
Text Books, and/or reference material	**Text Books:** • " The structure and dynamics of networks" by Newman, Barabasi, Watts, Princeton University Press. • "Networks: An Introduction" by Mark Newmann, Oxford University Press • "Network Science" by Barabasi, Cambridge University Press. **Reference Books:** • "Network Science" Theory and Applications by Ted G Lewis, Wiley. **Others:** • http://www.infocobuild.com/education/audio-video-courses/computer-

	science/complex-network-theory-iit-kharagpur.html (Video Lecture) by Dr. Animesh Mukherjee

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	3	1	2	1	-	-	-	-	2
CO2	1	3	3	2	1	1	-	-	-	-	-	1
CO3	3	2	3	1	2	1	-	-	-	-	-	1
CO4	3	3	3	2	2	1	-	-	-	-	-	1
CO5	1	1	1	1	2	1	-	2	2	3	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

CSE 723   Pattern Recognition   3-0-0   3 Credits   3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 723	Pattern Recognition	PEL	3	0	0	3	3
Pre-requisites Artificial Intelligence, Data Mining, DBMS, Object Oriented Programming		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Idea about Pattern and Pattern Class, Design of a Pattern Recognition System. • CO2: Idea of Instar, Outstar, Groups of Instar and Outstar, Different types of Memories. • CO3: Concept of Feedforward, Feedback and Competitive Learning Network. • CO4: Concept of Complex PR Tasks: RBF, RBF Network for Pattern Classification. • CO5 : Idea of Temporal Pattern Recognition: Concepts.						
Topics Covered	Pattern and Pattern Class: Design of a Pattern Recognition System, Syntactic and Decision Theoretic Approach, Bayesian Decision Theory, Continuous Features, Error, Risk and Loss. [4L] Parametric and Non Parametric Methods: Histogram Method – Kernel Based Methods – K - Nearest Neighbor Method -- Probabilistic Neural Network base on Parzon Window – PNN Learning. [3L] Basics of ANN: Instar , Outstar, Groups of Instar and Outstar, Different types of Memories. [3L]						

	PR Tasks: PR Problems, Different PR Tasks by FF, FB and Competitive Learning Network, Pattern Clustering, Feature Mapping Problem, Different Feature Mapping Network, Self Organizing Network. [4L] FF ANN: Pattern Association Network, Hebb's Law, Pattern Classification Network. [3L] FB ANN: Pattern Association, Pattern Storage, Pattern Environment Storage, Auto association , Hopfield Network, Capacity and Energy of a Hopfield Network, State Transition Diagram, Stochastic Network and Boltzmann Machine. [5L] Competitive Learning Network: Pattern Storage, Pattern Clustering Network, Minimal Learning, Malsburg Learning and Leaky Learning. [4L] Complex PR Tasks: RBF, RBF Network for Pattern Classification, Advantages of RBF over MLFF ANN, CPN Network. [3L] Single and Multilayer Network: Gradient Descent Procedure, Newton's Algorithm, Fixed Increment Learning, Variable Increment Learning, Support Vector Machine(SVM), Multilayer Neural Networks, Unsupervised Learning. [5L] Temporal Pattern Recognition: Concepts, Problems in temporal sequence, Architecture for temporal PR Tasks, Avalanche Structure, Jordon Network, Fully Connected Recurrent Network, Difference between Avalanche Network and Jordon Network. [4L] Similarity Measures: Mahalanabis Distance, Properties of Metrics, Minkowski Metric, Manhattan / City Block / L1 norm, Euclidean Distance L2 Norm, Maximum Value Distance L∞ Norm, Hamming Distance L1 norm. [4L]
Text Books, and/or reference material	**Text Books:** 1. Pattern Classification – Duda, Hart & Stork – J. Wiley & Sons. 2. Artificial Neural Networks – B. Yegnanarayana – PHI. **Reference Books:** 1. Neural Networks for Pattern Recognition – C.M. Bishop – Oxford.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	-	-	-	-	-	-	3
CO2	3	3	2	2	3	-	-	-	-	-	-	3
CO3	3	2	3	2	3	-	-	-	-	-	-	3
CO4	3	3	2	2	3	-	-	-	-	-	-	3
CO5	3	3	2	2	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 724 Semantic Web Technology 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE-724</td><td colspan="2">Semantic Web</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Data structure, DBMS, Web Technology, Basic Computer Logic</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Understating the philosophy of Semantic Web and Linked Data
CO2: Understanding the writing of own semantic web page by using publicly available vocabulary.
CO3: Design and publish own data in Open Data format, such that other people can discover it easily.
CO4: Able to develop different semantic web applications.
CO5: Getting exposure in this topic for further higher studies and research.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Principles of Linked Data, Introduction, A Layered Approach. (3L)
Naming Things with URIs, Making URIs Dereferenceable. (3L)
The Semantic Web (SW) vision: What is SW? The difference between Current web and SW, SW technologies, the Layered approach. (5L)
The XML Language, Structuring, Namespaces, Addressing and Querying XML Documents. (5L)
Resource Description Framework, RDF syntax, RDF Schema (RDFS). (7L)
Construction RDF and RDFS: Different syntax implementation, How to Store into server, Construction of RDFS. (5L)
SPARQL: Query Language: Syntax and Query processing. (2L)
Web Ontology Language OWL: OWL Syntax and Intuitive Semantics, OWL Species. (4L)
Description Logics, Model-Theoretic Semantics of OWL. (4L)
Ontology Engineering: Introduction, Constructing Ontologies, Reusing existing Ontologies. (2L)
Protégé tools. (2L)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1.Semantic Web Primer: second edition by Grigoris Antoniou and Frank van Harmelen.
2.Foundations of Semantic Web Technologies by Hitzler Pascal.
Reference Books:
1. Ontological Engineering by Asunción Gómez-Pérez, Mariano Fernández-López, and Oscar Corcho.
2. Linked Data: Evolving the Web into a Global Data Space by Tom Heath and Christian Bizer.
Others:
Harald Sack semantic web videos.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	3
CO2	2	3	1	2	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	2
CO5	1	2	2	3	3	1	-	-	-	1	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

CSE 725 Human Computer Interaction 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 725	Human Computer Interaction	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
NIL		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Acquire knowledge about Components of HCI. • CO2: To learn the basic Psychology of Usable Things. • CO3: To learn about Usability Engineering, Usability Benchmarking. • CO4: To learn Inspection methods, testing methods, design.						
Topics Covered	Introduction, Psychology of Usable Things. (7L) Usability Engineering, Know the User, Usability Benchmarking. (7L) Goal-Oriented Interaction Design, Prototyping. (7L) Usability Inspection Methods, Usability Testing Methods. (7L) Usability in Practice, Visual Design and Typography. (7L) Icon Design, Case Studies. (7L)						
Text Books, and/or reference material	**Text Books:** 1.Dix A., Finlay J., Abowd G. D. and Beale R. Human Computer Interaction, Pearson Education, 2005. 2.Preece J., Rogers Y., Sharp H., Baniyon D., Holland S. and Carey T. Human. ComputerInteraction, Addison-Wesley, 1994. **Reference Books:** B. Shneiderman, Designing the User Interface, Addison Wesley 2000. **Others:** NPTEL online course.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	1	1	1	1	1	1	1	1
CO2	2	2	3	2	1	2	1	1	1	1	1	3
CO3	3	2	3	2	2	2	1	1	2	2	2	3
CO4	3	2	2	1	2	1	1	1	2	1	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 726 Incentive Mechanisms in Computer Science 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE 726</td><td>Incentive Mechanisms in Computer Science</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid-Term (MT) end assessment (EA))</td></tr>
<tr><td colspan="2">1. Introduction to computing</td><td colspan="6">CT: 15%, MT: 25%, EA: 60%</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After completion of this course, the students
• CO1: Can have the efficiency to think about incentive issues in computation.
• CO2: Can learn the tools to tackle the incentive issues.
• CO3: Can understand the modern state of the art of incentive based computation.
• CO4: Can analyze the scenarios of incentive based computation.
• CO5: Can apply the knowledge in solving real life problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Motivation to the course with canonical ideas of game theory (3L)

Incentives in labour market: School Choice, Medical Residency matching, Kidney exchange, House allocationetc. (5L)

Auctions and Incentive issues. (5L)

Incentives in Voting, Knapsack Voting , Participatory Democracy (4L)

Incentives in P2P networks, Incentives for social participation (such as Stack Exchange etc.). (5L)</td></tr>
</table>

	Incentive study in selfish routing (3L) **Incentives in BGP routing** (2L) **Incentives in cryptocurrencies** (3L) **Reputation system and incentive issues** (2L) **Incentivizing Forecasts and Feedback** (2L) **Prediction Markets** (2L) **Time-Inconsistent Planning** (2L) **Fair Division** (4L)
Text Books, and/or reference material	**Text Books:** 1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829. 2. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791. **Reference Books:** 1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013 (Lecture Notes). 2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016 and later offerings (Lecture Notes).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	-	-	-	-	-	1	2
CO2	1	2	2	2	3	1	-	1	1	1	1	2
CO3	3	3	3	3	2	1	-	1	-	-	1	3
CO4	2	3	3	3	1	1	-	-	1	1	1	2
CO5	3	2	3	2	2	1	1	1	-	-	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EIGHTH SEMESTER

CSE 811 Distributed Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE811	Distributed Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Operating systems. Computer Networks		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: To explain the paradigm of distributed computing. • CO2: To explore various existing and possible architectures of distributed systems. • CO3: To properly appreciate the issues that arise in distributed systems and explore solutions for the problems. • CO4: To fully appreciate the advantages to be obtained from a distributed environment wrt fault tolerance, load sharing etc.						
Topics Covered	Introduction to Distributed Systems. Motivations. Design Issues. (3L) Clocks in a Distributed System. Synchronization Issues. Logical Clocks. Causal relationships. Vector Clocks. (3L) Distributed State Detection. Global State. Consistent Cut. Global State recording algorithm. (2L) Termination Detection. Credit based algorithm. Diffusion Computation based algorithm. (2L) Distributed Mutual Exclusion. Token based and non-token based algorithms. (4L) Deadlocks in Distributed Systems. Resource allocation Models. Deadlock Prevention. Deadlock Avoidance – Safe states. Deadlock detection and Correction. Phantom Deadlocks. Centralized, Distributed and Hierarchical deadlock detection algorithms. (5L) Fault recovery. Classes of Faults. Backward and Forward recovery. Log based recovery. Checkpoints. Shadow paging. (5L) Fault Tolerance. Data Replication. Quorum Algorithms. Distributed Commit Protocols. 2-phase commit. 3-phase commit. Election Algorithms. Bully algorithm. Ring topology algorithm. (8L) Byzantine faults and Agreement Protocols. (2L)							

	Distributed File systems. Mechanisms. Stateful and Stateless servers. Scalability. Naming and Name Servers. (4L) Distributed Scheduling. Load Balancing. Load Estimation. Stability. Process Migration. Remote Procedure Calls. Transparency. Binding. (4L)
Text Books, and/or reference material	**Text Books:** 1. Advanced Concepts in Operating Systems. Singhal and Sivaratri. McGraw Hill. **Refenence Books:** 1. Operating Systems: A Concept Based Approach. Dhamdhere. McGraw Hill. 2. Distributed Operating Systems: Concepts and Design. P.K.Sinha. Prentice Hall. 3. Distributed Operating Systems. A.Tanenbaum. Pearson Education. 4. Distributed Systems: Concepts and Design. Coulouris et.al. Pearson Education.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	3	3	2	3	3	2	-
CO2	3	2	3	2	2	2	2	2	2	3	2	-
CO3	3	2	3	2	2	2	2	2	2	3	2	-
CO4	3	2	3	2	2	2	2	3	3	3	3	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 812 Computer Vision 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 812	Computer Vision	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Probability and Statistics, Algebra, Optimization, Computer Graphics		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding basic architecture and principles of computer vision systems. • CO2: Implementation of computer vision algorithms including depth estimation, multi-camera view and motion analysis components. • CO3: Apply basic image processing and feature extraction techniques in						

	order to design computer vision algorithms. ● CO4: Analysis of pattern analysis and image segmentation techniques used for computer vision systems. ● CO5: Design and development of real time computer vision systems.
Topics Covered	Digital Image Formation and low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing. [5L] Depth estimation and Multi-camera views: Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration. Apparel. [6L] Feature Extraction: Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. [8L] Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection. [5L] Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. [8L] Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. [4L] Shape from X: Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation; Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges. [6L]
Text Books, and/or reference material	**Text Books:** ● Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011. ● D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003. **Reference Books:** ● Richard Hartley and Andrew Zisserman, Multiple View Geometry in

	Computer Vision, Second Edition, Cambridge University Press, March 2004. ● K. Fukunaga; Introduction to Statistical Pattern Recognition, Second Edition, Academic Press, Morgan Kaufmann, 1990. ● R.C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Wesley, 1992. **Others:** Swayam Online Course 1. https://swayam.gov.in/nd1_noc19_cs58/preview 2. https://www.coursera.org/courses?query=computer%20vision 3. https://www.edx.org/course/computer-vision-and-image-analysis-3 4. https://www.mooc-list.com/tags/computer-vision

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	-	-	-	-	-	-	2
CO2	2	3	3	3	2	-	-	-	-	-	-	2
CO3	2	2	3	2	3	-	-	-	-	-	-	2
CO4	2	3	2	3	2	-	-	-	-	-	-	2
CO5	2	2	3	3	3	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 813 Optical Networks 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 813	Optical Networks	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic Concepts of Computer Networks, and Algorithms		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	● CO1: Understanding the fundamental concepts and identifying different issues of optical networks. ● CO2: Comprehend the basic concepts and solution techniques for the different fundamental problems like routing and wavelength assignment (RWA), virtual topology design, wavelength rerouting, and traffic grooming in optical network design. ● CO3: Acquire knowledge of the wavelength convertible network. ● CO4: Comprehend the multicast routing in optical networks.						
Topics Covered	1. **Fundamentals and Different Problems**: Optical fiber principles, Optical transmission system, Wavelength Division Multiplexing(WDM), optical networking evolution, Optical Network Architectures, Different issues in						

	wavelength routed networks. (06L) 2. **Routing and Wavelength Assignment (RWA) algorithms**: ILP formulation of the RWA problem, Route Selection algorithms – Fixed Routing, Fixed Alternate Routing, Exhaust Routing, Least Congested Path Routing, Limited alternate Routing. Wavelength Selection algorithms. Joint wavelength-Route selection algorithm. (07L) 3. **Wavelength Convertible Networks**: Need for Wavelength Converters, Wavelength convertible Switch Architecture, Routing in Convertible Networks, Performance Evaluation of Convertible networks, Network with Sparse Wavelength Conversion, Converter Placement problem. (06L) 4. **Wavelength Rerouting Algorithm**: Benefits of wavelength rerouting, Issues in wavelength rerouting, Rerouting algorithm. (04L) 5. **Virtual Topology Design**: Physical and Virtual topology, Traffic routing over virtual topology, Limitations on virtual topology, Virtual topology problem formulation, Virtual topology design heuristics. (06L) 6. **Traffic Grooming:** Basic concepts, Grooming node architecture, ILP formulation of the traffic grooming problem, Different heuristics (MST, MRU, TGCP, etc) for the traffic grooming problem. (06L) 7. **Optical Multicast Routing**: Multicast routing problem, architecture of Light spliting node and MI node, Network with full splitting and sparse splitting, Multicast Tree generation algorithms – Source based, Steiner based and Virtual source based tree generation algorithms. (07L)
Text Books, and/or reference material	**Text Books:** **1.** WDM OPTICAL NETWORKS Concepts, Design and algorithms. by C. Siva Ram Murthy and Mohan Gurusamy (PHI). 2. OPTICAL NETWORKS by Biswanath Mukherjee (TMH). **Reference Books:** 1. Optical Networks: A Practical Perspective (3rd Edition) by R. Ramaswami, K. Sivarajan, G. Sasaki (Morgan Kaufmann Publishers).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1	-	-	-	-	-	-	2
CO2	2	3	3	3	2	-	-	-	-	-	-	3
CO3	2	3	3	2	2	-	-	-	-	-	-	3
CO4	2	3	3	2	2	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 814 Internet of Things 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 814	Internet of Things	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Understand the basic concepts of Internet of Things. • CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things. • CO3: Service computing models for IoT - edge computing, Machine learning mechanisms in IoT scenarios. • CO4: Able to understand the innovation opportunity in IoT application segments.
Topics Covered	**Module 1: Introduction to IoT and Sensing** (3L) Introduction to IoT, Sensing, Edge computing, Data processing, Learning. Introduction to layered architecture of IoT. **Module 2: Sensing and actuating** (4L) working principle of some sensors like Ultrasonic sensor, Thermal Sensors, Infrared Sensors, Pollutant Sensors, Temp, IMU Sensor etc.; basic actuation mechanisms and common actuators. **Module 3: Microcontroller/Microcomputer** (4L) Open source hardware, Play with Sensors using Arduino Programming, Local data processing using Raspberry Pi/Uddo Neo, using different Network Modules (Bluetooth, WiFi, GSM/GPRS). **Module 4:Wireless Networks Present and Future** (10L) Concept of TCP/IP protocol Stack, 802.11 Protocol (WiFi Network), LoRa Network, Acoustic Communication, Socket Programming, Wireshark Tool **Module 5: IoT Protocols** (4L) HTTP, QUIC, CoAP, MQTT. **Module 6:Performance and Security in IoT**(6L) Performance modeling of stochastic systems, QoS modeling, estimation of IoT service response times; fundamentals of lightweight security protocols. IS/ISO/IEC TR 22417: 2017 IoT general standards. **Module 7: Case Study of IoT Based Applications** (11L) Case Study 1: **(activity Identification)** Human Activity using Ultra sonic Sensors/Thermal Sensors. Case Study 2: **(Environment Monitoring)** Pollution Monitoring and Forecasting in Indoor and Outdoor. Case Study 3: **(Road Transportation System)** (a)Important PoIs using GPS trails,

	(b)Context Aware Speed Profiling from Mobile Phone Sensors, (c)My Smartphone Can Monitor My Street-lights. Case Study 4: **(Challenged Networks)** offline Crisis Mapper Design using ChatBot, IoT Protocol Stack Development using Acoustic Communication. Case Study 5: **(Agriculture Monitoring):** Smart Farming using MQTT Protocol through Cost-effective Heterogeneous Sensors. SmartCity IoT: Integration of multiple IoT application segments, dynamic directory management, service replication and server selection; putting it all together.
Text Books, and/or reference material	**Text Books** **1.** "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press). 2. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	2	1	-	-	1	-	1
CO2	3	2	2	2	1	1	1	1	-	1	-	2
CO3	2	3	2	1	3	2	2	2	1	2	1	1
CO4	-	3	2	3	3	3	2	2	2	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 815 Cloud Computing 3-0-0 3 Credits 3 Hour

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 815	Cloud Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	After the completion of this course, student will be able to: ● CO1: Understand the core concepts of the cloud computing paradigm: paradigm shift, the characteristics, advantages and challenges of various models and services. ● CO2: Apply fundamental concepts in cloud infrastructures to understand the tradeoffs in power, efficiency and cost, and then study how to leverage and manage single and multiple datacenters to build and deploy cloud applications that are resilient, elastic and cost-efficient. ● CO3: Learn system, network and storage virtualization and outline their role in enabling the cloud computing system model. ● CO4: Analyze the performance, scalability, and availability of the underlying cloud technologies and software. ● CO5: Identify security and privacy issues in cloud computing.						

	• CO6: Explain recent research results in cloud computing and identify their pros and cons.
Topics Covered	**Introduction to Services Oriented Computing -** Service Oriented Software, Web Applications Paradigm.[2] **Services Oriented Architecture -** SOA and Web Services Fundamentals, SOA and Service-Orientation, SOA - Planning and Analysis, SOA - Technology and Design, SOA Reference model (OASIS), SOA standard S3, Business Process and SOA, Software as a Service (SaaS) [4] **Web Services -** Introduction to Web Services, Web Service Jargon – Publishing, Discovery and Binding, Web Service Technologies – WSDL, SOAP, UDDI, Issues and Challenges – MANET, CLOUD, DTN,Formal, Representation of Services[4] **Cloud Computing Basics-** Overview, Applications, Intranets and the Cloud. Organization and Cloud Computing- Benefits, Limitations, Security Concerns. [2] **Cloud Infrastructure -** Data center, Virtualization, Clients, Security, Network, Services and Delivery Models (SaaS, PaaS, IaaS). Case study like Amazon EC2, Microsoft Azure etc. Deployment types (Private, Public, Hybrid) [4] **Software as a Service (Saas)-** Understanding the Multitenant Nature of SaaS Solutions, Understanding SOA. [2] **Platform as a Service (PaaS)-** IT Evolution Leading to the Cloud, Benefits of Paas Solutions, Disadvantages of Paas Solutions. [2] **Infrastructure as a Service (Iaas)-**Understanding IaaS, Improving Performance through Load Balancing, System and Storage Redundancy, Utilizing Cloud-Based NAS Devices, Advantages, Server Types. [3] **Virtualization-**Understanding Virtualization, History, Server Virtualization, Data Storage Virtualization. [4] **Securing the Cloud**- General Security Advantages of Cloud-Based Solutions, Introducing Business Continuity and Disaster Recovery. Disaster Recovery- Understanding the Threats. [4] **Migrating to the Cloud-**Cloud Services for Individuals, Cloud Services Aimed at the Mid-Market, Enterprise-Class Cloud Offerings, and Migration. [4] **Designing Cloud Based Solutions-**System Requirements, Design Is a Give-and-Take Process. Coding Cloud Based Applications-Creating a Simple Yahoo Pipe, Using Google App Engine and creating a Windows Azure Application. Application Scalability-Load-Balancing Process, Designing for Scalability, Capacity Planning Versus Scalability, Scalability and Diminishing Returns and Performance Tuning. [7]
Text Books, and/or reference material	**Text Books:** Cloud Computing: A Practical Approach by Anthony T. Velte Toby J. Velte, Robert Elsenpeter, The McGraw-Hill Publisher. Cloud Computing: SaaS, PaaS, IaaS, Virtualization and more. by Dr. Kris Jamsa, Jones & Bartlett Publisher. **Reference Books:** Cloud Computing Bible by Barrie Sosinsky, Published by Wiley Publishing. Cloud Computing for Dummies by Judith Hurwitz, Robin Bloor, Marcia Kaufman, and Dr. Fern Halper, Wiley Publishing. Cloud Computing Theory And Practice Danc.Marinercus, Elsevier.

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	-	-	2	-	1	2	-	-	-
CO2	1	2	3	-	2	1	1	1	1	-	-	-
CO3	1	1	-	-	2	2	1	-	2	-	-	-
CO4	3	2	2	3	2	2	-	-	1	-	-	1
CO5	-	1	2	3	1	3	-	3	-	-	-	2
CO6	3	3	1	3	2	-	-	-	-	-	-	3

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 816 Mobile Computing 3-0-0 3 Credits 3 Hours

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSE 816</td><td>Mobile Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Computer Networks</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduce the basics of Wireless Networks.
• CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things.
• CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems.
• CO4: Able to understand the innovation opportunity in IoT application segments.
• CO5: Hands-on experience on Wireless Networks & Mobile Computing.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Physical Layer (6 L)
Bit transmission over Wireless, Vary Much different from Wired Network.

Module 2: Mac Layer (8 L)
Access in Shared Medium, Difference between Wired MAC & Wireless MAC, Different Type of MACs (a) Random MAC (b) Scheduled MAC, Examples of MAC Implementation (WiFi Protocol --802.11, Bluetooth Protocol--805.15).

Module 3: Network Layer (8 L)</td></tr>
</table>

	Reactive Routing, Proactive Routing, DSR Principle, AODV Principle, Location Aware Routing. Adhoc Network, Delay Tolerant Network, Opportunistic Network Introduction, Architecture & Applications, Routing Algorithms – Epidemic, Prophet, Spray & Wait, Spray & Focus, Maxprop Simulation Tool - ONE Simulator. **Module 4:** Transport Layer **(8 L)** Wireless TCP and rationale, Difference between Wired TCP and Wireless TCP, QoS Measurement of Wireless Networks. **Module 5:** Modelling **(8 L)** Mathematical Modelling of Network Functionalities - Combining them to derived overall performance. **Module 6:** Case Study: Implementation of opportunistic Networks in Challenged Network scenarios **(4 L)** (a) Connection Mechanism (b) Sync - Transferring the information in Collaborative manner (c) Offline Dashboard (Information Summarization) (d)security
Text Books, and/or reference material	**Text Books:** 1. "Mobile Communication", by Jochen Schiller (PEARSON EDUCATION LIMITED). 2. "Wireless Networking" A kumar, D. manjunath, J. Kuri, Elsevier, 2008. 3. "Wireless Communication", T. S. Rappaport, Pearson, latest edition. **Reference Books:** **Research Papers:** 1. IEEE Infocom Tutorials slides by Prof. Nitin Vaidya. **Others:** Tools: ● Sniffer Tool (Wireshark) ● Simulation Tools: OMNET ONE NS3

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	-	1	-	-	-	-	-	-
CO2	2	2	3	2	-	2	-	-	-	2	-	-
CO3	2	2	2	2	3	3	3	1	-	-	-	3
CO4	2	1	3	3	-	3	-	-	-	-	3	-
CO5	2	3	3	3	3	3	3	-	3	3	2	3

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

CSE 817 Expert Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 817	EXPERT SYSTEMS	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Artificial Intelligence, Data Mining, Pattern Recognition, OOP	
	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**

Course Outcomes	
	• CO1: Idea about Knowledge Base & Expert Systems. • CO2: Idea of Inference Tool and Inference Engine and different methods of Inference Methodologies. • CO3: Idea about Reasoning under Uncertainty and Uncertainty Management which is really crucial under present day scenario. • CO4: Concept of the Design of Expert System Components and Experts Systems. • CO5: Some Examples of Practical Experts System.

Topics Covered

1. Introduction to Expert Systems: Definition of an Expert System – Advantages of Expert Systems – Characteristics of Expert Systems - Applications and Domains – Procedural and Non procedural Systems. [6L]

2. The Different Techniques for Knowledge Representation: Meaning of Knowledge – Productions – Semantic Nets- Frames – Logics – Propositional and Predicate Logic – The universal and existential quantifiers. [7L]

3. The Different Methods of Inference : Trees, Lattice and Graph – State and Problem Space – Rules of Inference – Logic Systems – Resolution Systems and Deductions – Forward and Backward Reasoning – Meta knowledge. [7L]

4. The Reasoning Under Uncertainty and Inexact Reasoning – Uncertainty – Types of Errors – Classical Probability – Experimental and Subjective probabilities – Compound and Conditional Probabilities – Temporal Reasoning – Uncertainty in Inference Chains – Evidence Combination – Uncertainty and Rules – Certainty Factors – Dempster- Shafer Theory – Approximate Reasoning. [8L]

	5. The Design of Expert Systems Tool and Expert Systems : Selecting Appropriate Problem – Stages in the development – Errors in Development – Expert System Life Cycle – A Life Cycle Model. [7L] 6. Some Practical Examples of Expert System Design – Modular Design – Phases and Control Facts – Importing and Exporting facts – Modules and Execution Control – Certainty Factors – Decision Trees – Backward Chaining – A Monitoring Problem.[7L]
Text Books, and/or reference material	**Text Books:** 1. Expert Systems Principles and Programming – Bikash Publishing House. 2. Pattern Classification- – Duda, Hart & Stork – J. Wiley & Sons. **Reference Books:** 1. Artificial Neural Networks – B. Yegnanarayana – PHI. 2. Neural Networks for Pattern Recognition – C.M. Bishop – Oxford.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	-	-	-	-	-	-	3
CO2	3	2	2	3	3	-	-	-	-	-	-	3
CO3	3	2	1	2	3	-	-	-	-	-	-	3
CO4	3	2	1	2	3	-	-	-	-	-	-	3
CO5	3	2	1	2	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 818 Ethics, Society, and Computer Science 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE818	Ethics, Society, and Computer Science	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic knowledge of programming and AI/ML		CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]					
Course Outcomes	• CO1: To understand professional and ethical responsibilities, including those defined in the ACM/IEEE Professional Code of Ethics. • CO2: To ensure fairness, accountability, and transparency while working on machine learning, artificial intelligence and related fields. • CO3: To appreciate the threats to privacy posed by modern data aggregation and data processing techniques. • CO4: To design technologies incorporating ethical considerations from the						

	specification provided.
Topics Covered	**Introduction:** What is Ethics?, Ethics and Computer Science, Social consensus on unethical practices by computer professionals, Conventional issues, Emerging issues in the age of data driven (AI/ML based) decision making, History and Evolution of ethics with advances in computer science and engineering. (4L) **Ethics in Data collection and aggregation:** Basic mechanism of data driven (AI/ML based) decision making, Data aggregation and decision making, Data Ownership, Collection and collation of digital imprints of users, Data stealing and data broking, Informed consent, Data repurposing, Privacy, Anonymity, Data validity, Establishing data protection framework with legal backing, Concept of differential privacy, GPDR. (10L) **Algorithmic Fairness:** Discriminatory impact of imperfect decisions, Case study: Facial recognition software, Criminal justice using big data, recidivism models for sentencing guidelines, predictive policing, Trust in AI/ML based decision making, Algorithmic fairness, Notions of fairness, Parity based and preference based notions, Fairness and accuracy, Identifying and mitigating inherent bias in data and/or machine learning algorithms, Proper choice of representative sample, Making training data fair, Designing fairness aware classifiers, Algorithmic audit, Challenges, Audit based on user survey, Sock puppet audit, Audit based on scrapping/crawling. (12L) **Transparency and Explainability:** Black-box phenomenon and trust, Unpredictability, Explanation/Reasoning, Right to explanation, Explainability and accuracy trade off, Transparency and interpretability, DARPA XAI, ML model explainability, Linear model explainability, Nonlinear model explainability, Neural networks explainability, LIME package, SHAP values, What-if tool. (5L) **AI Ethics:** Moral issues in autonomous and intelligent systems, Narrow (or Weak) AI and General (or Strong) AI, Weaponization of AI, Moral issues in autonomous robots, Robot ethics, Moral issues in self-driving cars, Moral Machine Quiz. (5L) **Personalization:** Personalized recommendation, search and newsfeed, Intellectual isolation associated with personalization, Objective search results, Personalized advertisement, Cross-domain tracking. (3L) **Code of Ethics:** Ethical standards by international professional societies, IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems, ACM Code of Ethics and Professional Conduct. (3L)
Text Books, and/or reference material	**Text Books:** 1. D J Patil, Hilary Mason, Mike Loukides, “Ethics and Data Science”, O'Reilly Media, Inc.; 1st edition (July, 2018). 2. P. Singer, “Practical Ethics”, Cambridge University Press, 3rd edition (February 2011)

	Reference Books: 1. Cathy O'Neil, "Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy", Crown; 1st edition (September 6, 2016). 2. John C. Havens, "Heartificial Intelligence: Embracing Our Humanity to Maximize Machines", TarcherPerigee; (February 2, 2016). 3. Wendell Wallach, Colin Allen, "Moral Machines: Teaching Robots Right from Wrong", Oxford University Press; 1st edition (June 3, 2010). 4. Garry Kasparov, "Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins", PublicAffairs; 1st edition (May 2, 2017).

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	-	-	-	2	-	1	-	-
CO2	3	3	3	3	-	1	2	-	2	2	3	-
CO3	3	3	3	3	1	1	3	-	2	2	3	1
CO4	2	2	1	1	3	3	1	2	-	-	-	2

Mapping of CO (Course Outcome) and PO (Programme Outcome)
Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CSE 819 Knowledge Management 3-0-0 3 Credits 3 Hour

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 819	Knowledge Management	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	CO1: Understand Knowledge and its creation, acquisition, dissemination, use and re-use. CO2: Understand KM systems and its application in knowledge generation and knowledge transfer CO3: Understand knowledge codification and system development, testing and deployment of KM systems. CO4: To evaluate effectiveness of KM System, draw inference from data,							

	data mining for knowledge extraction, understand role of KM Systems and Applications in institutes and organizations.
Topics Covered	KM concepts: Use of KM, KM System Life Cycle, aligning KM and business strategy (6L) Knowledge Types, KM System Life Cycle models (5L) Knowledge codification and system development, testing and deployment, Knowledge transfer and knowledge sharing (7L) KM systems: Analysis, design and development of KM System (5L) KM tools: inferences from data, data mining and knowledge portals (6L) Evaluation of KM effectiveness: Tools and metrics, Case studies on KM Systems and Applications (7L) KM experiences from Indian companies, KM innovation and Learning organization, The future of KM (6L)
Text Books, and/or reference material	**Text Books:** 1. Elias.M. Awad & Hassan M. Ghaziri – "Knowledge Management" Pearson Education. 2. Knowledge Management in Theory and Practice - 2nd edition by Kimiz Dalkir. **Reference Books:** 1. Guus Schreiber, Hans Akkermans, Anjo Anjewierden, Robert de Hoog, Nigel Shadbolt, Walter Van de Velde and Bob Wielinga, "Knowledge Engineering and Management", Universities Press. 2. C.W. Holsapple, "Handbooks on Knowledge Management", International Handbooks on Information Systems, Vol 1 and 2. **Others:** This course follows the structure of NPTEL Course on Knowledge Management by Prof. KBL Srivastava, IIT Kharagpur, link: https://nptel.ac.in/courses/110105076

Mapping of CO (course outcome) and PO (Program Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	1	3	3	3	3
CO2	3	3	3	3	3	3	3	1	3	3	3	3
CO3	3	3	3	3	3	3	3	1	3	3	3	3
CO4	3	3	3	3	3	3	3	1	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High)

Annexure - II

Note: CSC504 Microcontroller based Systems is now converted to CSC504 Embedded Systems.

CSC 504 Microcontroller based Systems 3-0-0 3 Credits 3 Hours

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC 504</td><td>Microcontroller based Systems</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
● CO1: Remember the architecture and instruction sets of PIC and ARM.
● CO2: Understand PIC interrupts, interfacing of peripherals.
● CO3: Apply the knowledge in LCD keyboard interfacing, ADC, DAC and Sensor interfacing and ARM assembly language programming.
● CO4: Analyze ADC, DAC and Sensor interfacing using PIC; relate PIC and ARM architectures.
● CO5: Appraise the architecture of PIC and ARM in terms of RISC architecture.
● CO6: Create embedded ARM applications.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
UNIT I INTRODUCTION TO PIC MICROCONTROLLER 9 14
Introduction to PIC Microcontroller–PIC 16C6x and PIC16C7x Architecture–PIC16cxx–- Pipelining - Program Memory considerations – Register File Structure - Instruction Set - Addressing modes –Simple Operations.
(12L)

UNIT II INTERRUPTS AND TIMER 9 PIC Microcontroller Interrupts- External Interrupts-Interrupt Programming–Loop time subroutine - TimersTimer Programming– Front panel I/O-Soft Keys– State machines and key switches– Display of Constant and Variable strings.
(8L)

UNIT III PERIPHERALS AND INTERFACING 9 I 2 C Bus for Peripherals Chip Access– Bus operation-Bus subroutines– Serial EEPROM—Analog to Digital Converter–UART-Baud rate selection–Data handling circuit–Initialization - LCD and keyboard Interfacing - ADC, DAC, and Sensor Interfacing. (8L)
</td></tr>
</table>

	UNIT IV INTRODUCTION TO ARM PROCESSOR 9 ARM Architecture –ARM programmer's model –ARM Development tools- Memory Hierarchy–ARM Assembly Language Programming–Simple Examples–Architectural Support for Operating systems. (10L) **UNIT V ARM ORGANIZATION 9 3-Stage Pipeline ARM Organization**– 5-Stage Pipeline ARM Organization–ARM Instruction ExecutionARM Implementation–ARM Instruction Set– ARM coprocessor interface– Architectural support for High Level Languages – Embedded ARM Applications. (4L)
Text Books, and/or reference material	**Text Books:** 1. Peatman,J.B., "Design with PIC Micro Controllers"PearsonEducation,3rdEdition, 2004. 2. Furber,S., "ARM System on Chip Architecture" Addison Wesley trade Computer Publication, 2000. **Reference Books:** 1. Mazidi, M.A.,"PIC Microcontroller" Rollin Mckinlay, Danny causey Prentice Hall of India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	1	1	1	1	1	1	1
CO2	2	2	2	1	1	1	1	1	1	1	1	1
CO3	2	2	2	1	1	1	1	1	1	1	1	1
CO4	2	2	2	1	1	1	1	1	1	1	1	1
CO5	2	2	2	1	1	1	1	1	1	1	1	1
CO6	2	2	2	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Annexure III

Modification of syllabus of some courses

CSE 719 Multimedia Information Systems 3-0-0 3 Credits 3 Hours

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSE 719	Multimedia Information Systems	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Knowledge of Data Structures and DBMS	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**

Course Outcomes	• CO1: In depth understanding of media and data stream, sound, audio, image, video and animation. • CO2: Understand multimedia compression techniques, multimedia operating systems fundamentals and multimedia network fundamentals. • CO3: Understanding multimedia synchronisation aspects, SAS factors, issues on dealing with multiple data formats, data encryption/decryption techniques. • CO4: Understanding of multimedia database storage and retrieval.
Topics Covered	Overview of multimedia system: Text, audio, video, graphics. Computer based animation-display of animation, animation languages, methods of controlling animation, transmission of animation. (6L) Media Synchronization and QOS (4L) Entropy, data compression, image compression, audio compression, video compression (10L) Multimedia Operating Systems issues like real time operation, resource management, process management, file systems, multimedia networking and communication fundamentals (9L) Data Encryption/Decryption techniques for media transmission (3L) Multimedia databases, query types, multimedia data storage and retrieval (10L)
Text Books, and/or reference material	**Text Books:** Multimedia Information Networking, Nalin K.Sharda, Prentice Hall India. Multimedia: Computing, Communications and Applications, Ralf Steinmetz and Klara Nahrstedt, Pearson Education Asia. Multimedia Communications, Applications, Networks, Protocols and Standards, Fred Halsall, Pearson Education Asia. Multimedia Systems, John F. Koegel Buford, Pearson Education Asia. **Reference Books:** Subrahmanian and Jajodia, Multimedia Database Systems, Springer. V.S. Subrahmanian, Principles of Multimedia Database Systems, Morgan Kaufmann Publishers, 1998.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	3	3	2	3	3	3	1	2	3	2	3
CO2	3	3	3	2	3	3	3	1	2	3	2	3
CO3	3	3	3	2	3	3	3	1	2	3	2	3
CO4	3	3	3	2	3	3	3	1	2	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN ELECTRONICS AND COMMUNICATION ENGINEERING

2021 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in _____ Senate # ______________ # Item no: ______

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Program Name: Bachelor of Technology in Electronics and Communication Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR ELECTRONICS AND COMMUNICATION ENGINEERING - B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4	4
2	ECC301	Network Analysis and Synthesis	3	1	0	4	4
3	ECC302	Electronic Devices and Circuits- I	3	1	0	4	4
4	ECC303	Signals and Systems	3	0	0	3	3

5	PHC331	Physics of Semiconductor Devices	3	0	0	3	3
6	PHS381	Semiconductor Devices Laboratory	0	0	3	1.5	3
7	ECS351	Network Analysis and Synthesis Laboratory	0	0	3	1.5	3
8	ECS352	Electronic Devices and Circuits Laboratory	0	0	3	1.5	3
9	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0	0
		TOTAL	15	3	9	22.5	27

Semester - IV

Sl.	Code	Subject	L	T	S	C	H
1	ECC401	Analog Communication	3	1	0	4	4
2	ECC402	Digital Circuits and Systems	3	1	0	4	4
3	ECC403	Electromagnetic Theory and Transmission Lines	3	1	0	4	4
4	EEC431	Control Systems	3	0	0	3	3
5	YYO44*	Open Elective - I	3	0	0	3	3
6	ECS451	Analog Communication Laboratory	0	0	3	1.5	3
7	ECS452	Digital Circuits and Systems Laboratory	0	0	3	1.5	3
8	EES481	Control Systems Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0	0
		TOTAL	15	3	9	22.5	26

Semester - V

Sl.	Code	Subject	L	T	S	C	H
1	ECC501	Digital Communication	3	1	0	4	4
2	ECC502	Microwave Engineering	2	1	0	3	3
3	ECC503	Microprocessors and Microcontrollers	3	1	0	4	4
4	ECC504	Electronic Devices and Circuits-II	3	1	0	4	4
5	YYO54*	Open Elective - 2	3	0	0	3	3
6	ECS551	Digital Communication Laboratory	0	0	3	1.5	3
7	ECS552	Microwave Engineering Laboratory	0	0	3	1.5	3
8	ECS553	Microprocessors and Microcontrollers Laboratory	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0	0
		TOTAL	15	4	9	22.5	27

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3	3
2	ECC601	Antenna and Wave Propagation	3	0	0	3	3
3	ECC602	VLSI Design	3	0	0	3	3
4	ECC603	Digital Signal Processing	3	1	0	4	4
5	ECE610 --	Depth Elective - 1	3	0	0	3	3
6	ECE610 --	Depth Elective - 2	3	0	0	3	3
7	ECS651	Antenna and Wave Propagation Laboratory	0	0	3	1.5	3
8	ECS652	VLSI Design Laboratory	0	0	3	1.5	3
9	ECS653	Digital Signal Processing Laboratory	0	0	3	1.5	3
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0	0
		TOTAL	18	1	9	23.5	28
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3	3
2	ECE710 --	Depth Elective - 3	3	0	0	3	3
3	ECE710 --	Depth Elective - 4	3	0	0	3	3
4	ECE710 --	Depth Elective - 5	3	0	0	3	3
5	YYO74*	Open Elective - 3	3	0	0	3	3
6	ECS751	Computer Aided Design Laboratory	0	0	3	1.5	3
7	ECS752	Electronic System Design Laboratory	0	0	4	2	4
8	ECS753	Advanced Communication Laboratory	0	0	3	1.5	3
9	ECS754	Vocational Training / Summer Internship and Seminar	0	0	2	1	2
10	ECS755	Project - I	0	0	3	1	3
		TOTAL	15	0	15	22	30
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ECE810 --	Depth Elective - 6	3	0	0	3	3
2	YYO84*	Open Elective - 4	3	0	0	3	3
3	YYO85*	Open Elective - 5	3	0	0	3	3
4	ECS851	Project - II	0	0	15	5	15
5	ECS852	Project Seminar	0	0	0	1	0
6	ECS853	Comprehensive Viva Voce	0	0	0	1	0
		TOTAL	9	0	15	16	24

CREDIT UNIT OF THE PROGRAM:

Semester	**I + II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**TOTAL**
Credit Unit	45	22.5	22.5	22.5	23.5	22	16	174

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING	
ECE610	Artificial Intelligence & Soft Computing
ECE611	Computer Organization and Architecture
ECE612	Advanced Digital Communication
ECE613	Object Oriented Programming
ECE614	ASIC Design using Verilog/VHDL
ECE615	Active Filter Design
ECE616	VLSI Technology
ECE617	Probability and Random Signal Theory
ECE618	Data Comm. & Computer Networks
ECE619	Mobile Computing
ECE620	Nanoelectronics
ECE621	Measurement & Instrumentation
ECE622	Digital IC Design
ECE623	Mechatronics Systems
ECE624	Power Electronics
ECE625	Optical Communication

7th Semester

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING	
ECE710	Detection and Estimation Theory
ECE711	Information Theory & Coding
ECE712	Analog IC Design
ECE713	FPGA Based Design
ECE714	MEMS and Microsystems Technology
ECE715	Machine Learning
ECE716	Millimetre Wave Technology
ECE717	RF ID Technology and Applications
ECE718	VLSI System Design
ECE719	Telecommunication Networks
ECE720	Advanced Semiconductor Devices
ECE721	Random Processes
ECE722	Microwave Circuits & Techniques
ECE723	Semiconductor Device Modelling
ECE724	Biomedical Instrumentation
ECE725	Adhoc and Sensor Networks

8th Semester

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING	
ECE810	Wireless Communication
ECE811	Mixed Signal IC Design
ECE812	Broadband Communication

ECE813	Digital Image Processing
ECE814	Error Control Coding
ECE815	Embedded System Design
ECE816	RF and MMIC
ECE817	Design with Op. Amps. & Analog Integrated Circuits
ECE818	Satellite Communication
ECE819	RF IC Design
ECE820	Low Power Circuits & Systems
ECE821	Advanced Antenna Synthesis
ECE822	DSP Architectures in VLSI
ECE823	Internet of Things (IoT) Technology
ECE824	VLSI Testing and Verification
ECE825	Statistical Signal Processing

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						

Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHC01</td><td>Engineering Physics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites:</td><td colspan="5">Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems.
CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field.
CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization.
CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Harmonic Oscillations - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8]
Wave Motion - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3]
Introductory Quantum Mechanics - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8]
Interference & Diffraction - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13]
Polarisation - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5]
Laser and Optical Fiber - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons
2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications
3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill.
REFERENCE BOOKS:</td></tr>
</table>

	1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel.						

	(2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	<u>Suggested Text Books:</u> (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall <u>Suggested Reference Books:</u> **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application						
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]						

Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]

Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3]						

	Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education)

	3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.						
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil						
	<u>Suggested Text Books:</u> 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra <u>Suggested Reference Books:</u> 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>WSS51</td><td>WORKSHOP PRACTICE</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">

CO1: Study and practice on machine tools and their operations
CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4: Develop basic electrical engineering knowledge for house wiring practice
</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">
M/c shop & Carpentry shop -- 3X3= 9hrs.

Introduction on machining process.
Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
Introduction to woods- Types, structure, disease and defect of wood.
Introduction to wood working machines and tools.
Making of dovetail joint and bridle joint.

Welding Shop & Sheet metal -- 3X3= 9hrs.

Introduction to welding.Safety and precautions in welding.
Formation of weld bead by SMAW on mild steel flat.
Formation of weld bead by oxy-fuel welding on mild steel flat.
Introduction to sheet Metal works.
Tools and Machines used in sheet metal works.
Concept of development, marking out of metal sheets.
Cutting and joining of metal sheets.
Safety precautions, General warning needed in the shop floor.

Black smithy & Foundry -- 3X3= 9hrs.

Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
Safety and precautions in blacksmithy.
Making of bars of different cross-sections.
Making of hexagonal headed bolts.
Forge welding.
Introduction to Foundry Technology.
Preparation of sand mould using Solid/Split Pattern.

Fitting & Electrical shop -- 3X3= 9hrs.

Introduction to hand metal cutting tools with specifications, nomenclature and their use.
Marking tools, measuring tools and their use.
Fitting of joints of mild steel flats.
Introduction to electrical hazards and safety precaution.
</td></tr>
</table>

	• Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service

<table>
<tr><td>Topics Covered</td><td>
YOGA

Introduction of Yoga.
Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar.
Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra.
Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani.
Meditation- Yognidra, Om chant, Pray chant.
Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana.
Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi.
Kriya- Kapalbhati, Trataka.

ATHLETICS

Introduction of Athletic.
Starting Technique for Track events- Standing start, Crouch & Block start.
Finishing Techniques.
Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules.
Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance.

BASKETBALL

Introduction and Players stance and ball handling.
Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass.
Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running.
Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble.
Rules of Basketball.
Basketball game.

VOLLEYBALL

Introduction of Volleyball
Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service.
Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set.
Rules and their interpretation.

FOOTBALL

Introduction of Football
Push pass- Instep inside, Instep outer side.

</td></tr>
</table>

	• Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt,

	Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC 02</td><td>MATHEMATICS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic concepts of set theory, differential equations, and probability.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
• CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
• CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
• CO4: To grasp the basic concepts of probability theory.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Elementary algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (5)
Linear Algebra: Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear</td></tr>
</table>

	equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian
	determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4) **Laplace and Fourier Transforms:**Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10^{th}ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3^{rd} Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					

Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium 1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons 1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes**						

	2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier

	9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.
• CO4: introduce the basic concept of single-phase transformer.
• CO5: analyze the transient phenomena in electrical circuits with DC excitation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Overview of Electrical power generation systems (2)
Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4)
Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4)
Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8)
Transients with D.C. excitation for R-L and R-C circuits. (3)
Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10)
Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6)
Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)</td></tr>
</table>

Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them						
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications						

	Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy,

	favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour)						

	8. Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS 51</td><td>Basic electronics Lab</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire idea about basic electronic components, identification, and behavior.
• CO2: To determine IV characteristics of these Circuit elements for different applications.
• CO3: Learn to analyze the circuits and observe and relate input and output signals.</td></tr>
<tr><td>Labs Conducted.</td><td colspan="7">1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments.
2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it.
3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms.
4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.
5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs
6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs
7. Transistor as a Switch: study and perform transistor as a switch through NOT gate
8. Zenner diode as voltage regulator
9. To study clipping and Clamping circuits
10. To study different biasing cirtis.
11. Study of CE amplifier and observe its frequency response.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al.
<u>Reference Books</u>:
1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill
2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="10">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td colspan="2">ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: understand the principle of superposition.
• CO2: understand the principle of maximum power transfer
• CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp.
• CO4: understand the calibration of energy meter.
• CO5: understand open circuit and short circuit test of single-phase transformer.
• CO6: analyze RLC series and parallel circuits
• CO7: understand three phase connections.
• C08: understand determination of B-H curve</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">List of Experiments:
1. To verify Superposition and Thevenin's Theorem.
2. To verify Norton and Maximum power transfer theorem
3. Characteristics of fluorescent and compact fluorescent lamp
4. Calibration on energy meter
5. To perform the open circuit and short circuit test on single phase transformer
6. To study the balanced three phase system for star and delta connected load
7. Characteristics of different types of Incandescent lamps
8. Study of Series and parallel R-L-C circuit
9. Determination of B-H Curve for magnetic material</td></tr>
<tr><td colspan="2">Textbooks, and/or reference material</td><td colspan="7">Textbooks:
1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma , H U Ezea
2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3

CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>XXS-52</td><td>Co-curricular Activities</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Pre-requisites</td><td colspan="7">Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)</td></tr>
<tr><td>NIL</td><td colspan="7">CE + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Social Interaction: Through the medium of sports
• CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them
• CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.
• CO4: Personality development through community engagement
• CO5: Exposure to social service</td></tr>
<tr><td>Topics Covered</td><td colspan="7">YOGA
• Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana.
• Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra.
• Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana.
• Meditation- ‘Om’meditation, Kundalini or Chakra Meditation, Mantrameditation.
• Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose).
• Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari.
• Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha.
• Kriya- Kapalabhati, Trataka, Nauli.
ATHLETICS
• Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing</td></tr>
</table>

	• Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice.

TABLE TENNIS

- Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.
- Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.
- Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin.
- Service: Backhand/Forehand- Push service, Deep push service, Rally service.
- Service: Backhand sidespin (Left to right & Right to left).
- Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service.
- Rules and their interpretations.
- Table Tennis Match (Singles & Doubles).

NCC

- FD-6 Side pace, Pace Forward and to the Rear.
- FD-7 Turning on the March and Wheeling.
- FD-8 Saluting on the March.
- FD-9 Marking time, Forward March and Halt in Quick Time.
- FD-10 Changing step.
- FD-11 Formation of Squad and Squad Drill.
- FD-12 Parade practice.

TAEKWONDO

- Poomsae (Forms)- Jang, Yi Jang.
- Self Defense Technique- Self defense from arms, Fist and Punch.
- Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring).
- Combination Technique- Combined kick and punch.
- Board Breaking (Kyokpa)- Sheet breaking.
- Interpretation Rules above Technique of Taekwondo.

NSS

- No Smoking Campaign
- Anti- Terrorism Day Celebration
- Any other observation/celebration proposed by Ministry/institute
- Public Speaking
- Discussion on Current Affairs
- Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

THIRD SEMESTER

<table>
<tr><td colspan="10">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td colspan="2">MATHEMATICS-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic knowledge of topics included in MAC01 & MAC02.</td><td colspan="7">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="8">CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="8">Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]

Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange’s interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson’s 1/3 rule for numerical integration; Euler’s method and modified Eular's methods for solving first order differential equations. [14]

Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation</td></tr>
</table>

	and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar&R.K.Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig <u>Suggested Reference Books</u>: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2		2			2	2	3
CO2	1	2	1	1			3		2	1		3
CO3	3			2		1	2		2			3

CO4	3	3	3	2			1	2	1		2	3

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 56</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC301</td><td>Network Analysis and Synthesis</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
Continuous (CT), Mid-Term (MT), End Assessment (EA)</td></tr>
<tr><td colspan="3">Engineering Physics (PHC01),
Mathematics I and II (MAC01, MAC02)</td><td colspan="5">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On successful completion of this course, students should have the skills and knowledge to:
CO1. Applications of network theorems and Laplace transform in A.C. and D.C circuit analysis, time domain analysis of simple RLC circuits, transient analysis.
CO2. Graph Theory. Characterization of two port networks and Z, Y, ABCD and h parameters, inter-relationships between the parameters.
CO3. Representation of two port network in terms of T , Π and lattice networks, Bisection theorem and its applications, image impedance,characteristic impedance and propagation function
CO4. Design of various types of attenuators and determination of insertion loss
CO5.Design of prototype low pass, high pass, bandpass and bandstop filters, constant K-type filters, modern filter design concepts, application of filters.
CO6.Synthesis of LC, RC and RL driving point admittance functions using Foster and Cauer first and second forms.</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Unit I:Network Functions and Transient analysis (L=08 hrs.+ T=3 hrs.)
Transform Impedances,Network Theorems, Network functions of one port and two port networks, concept of poles and zeros, properties of driving point and transfer functions, time response and stability from pole zero plot, Laplace transform of various functions, Applications of Laplace transform in A.C. and D.C circuit analysis, Time domain analysis of simple RLC circuits, transient analysis.
Unit II: Two Port Networks (L=09 hrs.+T=3hrs.)
Characterization of two port networks, Z, Y, ABCD and h parameters, Reciprocity and symmetry. Inter-relationships between the parameters, Inter-connections of two port networks, T & Π Representation, Bisection theorem, Lattice network, Image impedance, Characteristic impedance and propagation function
Unit III: Network Topology (L=04 hrs +T=2 hrs.)
Network graph, Tree, Incidence matrix - Fundamental cutsets and fundamental loops – Tie set and cut set schedules – V shift and I shift – Formulation of equilibrium equation on loop basis and node basis, Formulation of equilibrium equation in matrix form – Duality, Construction of dual of a network.
Unit IV: Attenuators (L=05 hrs.+ T=2 hrs.)
Image and scattering parameters, insertion loss. Various types of attenuators (Lattice, T, Π etc. networks).
Unit V: Filters (L=07 hrs.+ T=3 hrs.)
Filters: conditions of passband and stopband, design of prototype low pass, high pass, bandpass and bandstop sections, constant K-type filters, modern filter design</td></tr>
</table>

	concepts, application of filters. **Unit VI: Network Synthesis(L=07 hrs.+ T=3 hrs.)** Hurwitz polynomials and properties – Positive real functions and its properties; definition and properties; properties of LC, RC and RL driving point functions, synthesis of LC, RC and RL driving point admittance functions using Foster and Cauerfirst and second forms.
Text Books, and/or Reference material	**Text Books**: 1. E. Van Valkenburg, "Network Analysis", Prentice Hall of India 2. C. L Wadhwa, "Network Analysis and Synthesis" New Age International Publishers, 2007, 3. D. Roy Choudhury, "Networks and Systems" Wiley Eastern Ltd. 4. John D. Ryder, "Networks, Lines & Fields", 2nd edition, Pearson
	Reference Books/materials: 1. B. C. Kuo, "Network Analysis and Synthesis", John Wiley 2. E. Van Valkenburg, "An Introduction to Modern Network Synthesis", Wiley Eastern Ltd. 3. A. Chakrabarti, "Circuit Theory" DhanpatRai& Co.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	1	-	-	-	-	-	-	3	2	3	2
CO#2	3	3	2	3	2	-	-	-	-	-	-	3	3	2	2
CO#3	3	3	3	3	2	-	-	-	-	-	-	3	3	3	2
CO#4	3	2	2	3	2	-	-	-	-	-	-	2	3	3	2
CO#5	3	3	3	3	2	1	-	-	-	-	-	2	3	2	2
CO #6	3	2	3	3	2	-	-	-	-	-	-	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC302	Electronic Devices and Circuits-I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods: Continuous (CT), Mid-Term (MT), End Assessment (EA)					
Engineering Physics (PHC01), Electrical Technology (EEC01), Basic electronics (ECC01)		The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.					
Course Outcomes	CO # 1. Understanding the fundamental knowledge of analog devices and circuits CO # 2. To become familiar with the design of much more complex electronic circuits with the help of those fundamentals. CO # 3. Enriching historical developments with facts that led to this theory. Emphasis is given on IC technology but it originates from vacuum tube era. CO # 4. To be aquatinted with the present day design tools using which one can synthesize						

	and analyze the complex design problems. CO # 5. Understanding the devices and circuits as a basic building block of electrical communication and other areas and enhancing problem solving skills.
Topics Covered	**1. P-N Junction Diode:(4L+1T)** Qualitative Theory of P-N Junction, P-N Junction as a Diode, Diode Equation, Volt-Ampere Characteristics, Temperature dependence of V-I characteristic, Ideal versus Practical – Resistance levels(Static and Dynamic), Transition and Diffusion Capacitances, small Signal Model and Its Application, Diode Equivalent Circuits, Load Line Analysis, Breakdown Mechanisms in Semiconductor Diodes, Zener Diode Characteristics. **2. Special Purpose Electronic Devices: (4L+1T)** Principle of Operation and Characteristics of Tunnel Diode (with the help of Energy Band Diagram), Varactor Diode, SCR and Semiconductor Photo Diode. **3. Rectifiers and Filters :(4L+1T)** The P-N junction as a Rectifier, Half wave Rectifier, Full wave Rectifier, Bridge Rectifier, Harmonic components in a Rectifier Circuit, Inductor Filters, Capacitor Filters, L- Section Filters, π- Section Filters, Comparison of Filters, Voltage Regulation using Zener Diode. **4. Bipolar Junction Transistor and UJT: (6L+2T)** The Junction Transistor, Transistor Current Components, Transistor as an Amplifier, Transistor Construction, BJT Operation, BJT Symbol, Common Base, Common Emitter and Common Collector Configurations, Limits of Operation, BJT Specifications, BJT Hybrid Model, Determination of h-parameters from Transistor Characteristics, Comparison of CB, CE, and CC Amplifier Configurations, UJT and Characteristics; BJT small signal model – Analysis of CE, CB, CC amplifiers- Gain and frequency response **5. Transistor Biasing and Stabilization:(7L+2T)** Operating Point, The DC and AC Load lines, Need for Biasing, Fixed Bias, Collector Feedback Bias, Emitter Feedback Bias, Collector - Emitter Feedback Bias, Voltage Divider Bias, Bias Stability, Stabilization Factors, Stabilization against variations in V_{BE} and β, Bias Compensation using Diodes and Transistors, Thermal Runaway, Thermal Stability, Analysis of a Transistor Amplifier Circuit using h – Parameters: **AC Models:** Base-Biased Amplifier, Emitter-Biased Amplifier, Small-Signal operation, AC Beta, AC Resistance of the Emitter Diode, Two Transistor models, Analyzing an Amplifier **6. Field Effect Transistor:(7L+2T)** The Junction Field Effect Transistor (Construction, principle of operation, symbol) – Pinch-off Voltage - Volt-Ampere characteristics, The JFET Small Signal Model, MOSFET (Construction, principle of operation, symbol), MOSFET Characteristics in Enhancement and Depletion modes. FET Amplifiers: FET Common Source Amplifier, Common Drain Amplifier, Generalized FET Amplifier, Biasing FET, FET as Voltage Variable Resistor, MOSFET small signal model– Analysis of CS, CG and CD amplifiers – Gain and frequency response- High frequency analysis. Comparison of BJT and FET amplifiers. **7. Multistage Amplifiers: (6L+2T)** Introduction; Amplifier frequency response, Gain Bandwidth product, Need for multi-stage amplification; R-C coupled amplifiers, Cascode configuration **8. Operational Amplifiers: (6L+2T)** Basics of operational amplifiers, open loop and closed loop response, Application of op–amps (Non–linear applications): viz, inverting and non inverting amplifiers, voltage follower, adder, substractor, differentiator and integrator, Comparators, clippers and clampers, Schmitt triggers, precision rectifiers, peak detectors, Log and Antilog amplifiers, gyrator, Current to voltage and voltage to current converters, Instrumentation and isolation amplifiers, transducer Bridge amplifiers. General op–amp

	circuit design and detailed circuit description.
Text Books, and/or reference material	**Text Books:** 1. J. Millman, C.C.Halkias, "Electronic Devices and Circuits" 2. Thomas L. Floyd, "Electronic Devices", 8th Edition, Pearson Education Inc., 2007 **Reference Books:** 1. Mohammad Rashid, "Electronic Devices and Circuits" Cengage Learing, 2013 2. Schilling and Belove, "Electronic Circuits: Discrete and Integrated",McGraw-Hill Education , 3rd Ed. 3. Robert Boylestad and Louis Nashelsky, " Electronic Device and Circuit Theory", PHI; 9th Edition, 2007 4. A.S. Sedra and K.C. Smith, "Microelectronic Circuits", 6th Edition, Oxford University Press, 2006 5. David A. Bell, "Electronic Devices and Circuits" 5 Ed, Oxford

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#2	2	2	3	2	3	1	-	-	-	-	-	2	2	3	2
CO#3	2	2	3	3	3	2	1	-	-	-	-	2	3	3	3
CO#4	2	3	2	3	3	-	-	-	-	-	-	-	3	3	2
CO#5	2	3	3	3	3	-	-	-	-	-	-	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC303	Signals and Systems	PCR	3	0	0	3	3
Prerequisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Mathematics I and II (MAC01, MAC02)		The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.					
Course Outcomes		• CO1: To realize the difference between (i) continuous and discrete signals, (ii) analog and digital signals. • CO2: Understand mathematical techniques to solve problems involving convolution, filtering, modulation and sampling. • CO3: Ability to apply mathematical transforms for signals and systems analysis. • CO4: Analysis of stable LTI systems.					

<table>
<tr><td></td><td colspan="3">• CO5: Practical realization of various forms of anti-aliasing filters.</td></tr>
<tr><td>Topics Covered mapped to Course Outcomes</td><td><u>Topic Details</u>

Classification of signals, basic operation on signals such as time scaling and time shifting, elementary signals, impulse function, introduction to system properties such as stability, memory, causality, invertibility, time invariance and linearity.
Analyzing linear time invariant (LTI) systems through convolution sum and convolution integral, correlation of signals, relation between convolution and correlation, interconnection of LTI systems, relations between LTI system properties and impulse response, step response.
Analyzing LTI systems through discrete time difference equation and continuous time differential equation models, natural response, forced response, transient response and stability.
Concepts on Fourier series, Discrete time Fourier series, Fourier transform and Discrete time Fourier transform. Thorough analysis of the properties of Fourier representations in connection with real time systems.
Relationship between the various Fourier representations, applications of Fourier representation to mixed signal classes, analyzing sampling of signals through Fourier transforms.
Discrete Fourier transform, properties of DFT, circular convolution, computations for evaluating the DFT, decimation in time and decimation in frequency FFT algorithms.
Other essential transforms:
Hilbert transforms, properties of Hilbert transforms, representation of complex envelope and bandpass signals.
Haar transform, wavelet functions, continuous and discrete wavelet transforms, non-adaptive and adaptive transform coding, wavelet coding.
Complex frequency concept, Bilateral and Unilateral Laplace transforms, properties, inversion, solving differential equations with initial conditions, transfer function, causality and stability analysis, determining the frequency response from poles and zeros.
Z transform, properties, inversion, transfer function, causality and stability, determining the frequency response from poles and zeros, computational structures for implementing discrete time LTI systems.
Application to linear feedback systems, sensitivity and</td><td><u>(No. of classes)</u>

2

5

3

8

4

3

5

4

4

4</td><td><u>Course Outcomes (COs)</u>
CO#1, CO#4

CO#2, CO#4

CO#2, CO#4

CO#3

CO#2,CO#3, CO#5

CO#2, CO#3, CO#5 (Self-Learning Module)
CO#2, CO#3, CO#4

CO#3, CO#4

CO#3, CO#4

CO#2, CO#4 (Self-Learning Module)</td></tr>
</table>

	distortion analysis, stability problem, Routh-Hurwitz criterion, Nyquist stability criterion, sampled data feedback systems.		
Text Books, and / or reference material	**Text Books**: 1. Signals and Systems -- Simon Haykin. 2. Principles of Linear Signals and Systems -- B.P.Lathi 3. Signals and Systems --Tarun Kumar Rawat **Reference Books**: 1. Signals and Systems: Schaum's Outline. 2. Discrete-Time Signal Processing -- Oppenheim, Schafer and Buck. 3. Digital Signal Processing-- Proakis and Manolakis. 4. a Wavelet tour of signal processing, The Sparse Way -- StéphaneMallat.		

COURSE ARTICULATION MATRIX

Mapping the Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#2	1	2	3	3	3	-	-	-	-	-	-	3	3	2	2
CO#3	2	1	3	3	3	-	-	-	-	-	-	3	3	2	2
CO#4	2	3	3	3	2	-	-	-	-	-	-	3	3	2	2
CO#5	1	1	3	3	3	-	1	-	-	-	-	3	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC331	Physics of Semiconductor Devices	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Engineering Physics (PHC01)		CT+MT+EA					
Course Outcomes	At the end of the course, a student will be able to: **CO1**.Describe the different electronic properties of semiconductor materials. **CO2**. Understand the working principal of electronic devices (PN Diode, Photodetector, Solarcell, Light-EmittingDiodes, Laser Diodes, JFET, MOSFET, Tunnel Diode, Gunn Diode, IMPATT Diode, TRAPATT Diode and semiconductor memory). **CO3**. Apply the knowledge of memory expansion to design required expanded memory for specific application.						
Topics Covered	**Fundamentals of Semiconductor & SemiconductorDevicesFabrication:** Introduction to crystal growth, Intrinsic and extrinsic semiconductors, Fermi level, Conductivity, Mobility and its temperature dependence, Energy bands of semiconductors, Direct and indirect semiconductor, Variation of energy band with alloy composition, III-V and II-VI alloy semiconductor, Homo and hetero-structure						

	semiconductor, Effective masses of carriers in semiconductor, Fermi-Dirac distribution function, Density of states, Carrier concentrations at equilibrium, Calculation of number density of carriers and their temperature dependence, Effects of temperature on carrier concentrations, High field effects, Hall effect, Lithography, Optical lithography and Electron beam lithography. **[14L]** **Junction-Diode&OptoelectronicDevices:** P-N junction, Contact potential, Banddiagram, Degenerate semiconductors, Photodetector,Solarcell, Light-EmittingDiodes, Internal and external quantum efficiency etc.,SemiconductorLasers, Population inversion at a junction, Emission spectra for P-N junction Lasers.**[3L]** **Negative Conductance Microwave Devices:** Materials for negative conductance devices, The Gunn effect and related devices, The transferred electron mechanism, Transit time devices, The IMPATT Diode, the TRAPATT Diode, TunnelDiode. **[10L]** **JFETandMOSFET:** JunctionFieldEffectTransistors(JFET),Operation,I-VCharacteristics etc.,MOSstructure, Different MOS structures, Operation of MOS at high and low frequency, Accumulation, Inversion, strong inversion regions,Metal-OxideSemiconductor FieldEffectTransistors(MOSFET),MOSFETasaCapacitor,MOSFETasa resistorandrelatedcircuits. **[9L]** **Semiconductor Memory Device:** Semiconductormemoryorganization,RandomAccessMemory(RAM)(staticanddynamic),CMOS memorycircuits,ChargeCoupledDevices (CCD).**[6L]**
Text Books, and/or reference material	**Text Books:** 1. PhysicsofSemiconductorDevices,SMSZE. 2. SolidStateElectronicDevices,BenGStreetman & Banerjee 3. Microwave Solid-State Devices, S Y Liao **Reference Books:** 1. SemiconductorPhysicsand Devices,Donald A.Neamen. 2. Microwave Engineering, David M.Pozar. 3. IntegratedElectronics,Millman-Halkias.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome):

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	1	2	1	-	1	1	1	-	-	-	2	-	-	1
CO#2	3	2	1	1	1	1	1	1	1	1	-	2	1	1	1
CO#3	3	3	2	1	1	1	1	1	1	1	1	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 27				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS351	Network Analysis and Synthesis Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods: Continuous (CT) and End Assessment (EA)					
Electrical Technology (EEC01)		CT+EA					

Course Outcomes	CO#1 Understand the basics of DC (direct current) circuits. CO#2 Use Mutisim Simulator for circuit simulation CO#3 Able to apply network circuit theorems to analyze electrical circuits CO#4 Use an oscilloscope to measure frequency, period, voltage (magnitude, peak-to-peak, maximum, minimum, and etc), DC offset, etc, of the waveform CO#5 Understand the difference between over-damped, critically damped and under-damped circuits from the observation of step response.
Laboratory experiments covered	1. Experiment with DC Measurements 2. Experiment with AC Measurements 3. Experiment with Network Analysis Methods 4. Experiment with First Order Circuits 5. Experiment with Second Order Circuits 6. Experiment with Sinusoidal Steady State 7. Experiment with Series & Parallel Resonance 8. Experiment with Transfer Functions 9. Experiment with Frequency Response Approach: Laboratory experiments of this course are devoted to elementary design of linear circuits. In particular, time is devoted to (a) the transient voltage response of RC, RL and RLC circuits, (b) the sinusoidal steady-state response of RC, RL and RLC circuits, and (c) the frequency response of series RLC resonance networks, and the impacts on the frequency response by varying capacitance and resistance.
Text Books, and/or reference material	Reference Books/ Materials: 1. B. C. Kuo, "Network Analysis and Synthesis", John Wiley 2. E. Van Valkenburg, "An Introduction to Modern Network Synthesis", Wiley Eastern Ltd. 3. Teri L. Piatt (Author), Kyle E. Laferty, "Circuit Analysis Laboratory Workbook (Synthesis Lectures on Electrical Engineering) Lab Manual, Workbook Edition" Morgan & Claypool. 4. Laboratory Instruction Manual.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	1	-	-	-	1	1	-	1	2	1	1
CO#2	3	2	2	1	1	1	-	1	1	1	-	1	2	1	1
CO#3	3	3	3	1	1	-	-	-	1	1	-	1	3	3	2
CO#4	1	2	1	1	1	-	-	-	1	1	-	1	3	3	2
CO#5	2	3	1	2	1	-	-	-	1	1	-	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Course Name	Program Core (PCR)/Elective (PEL)	Total Number of contact hours = 27				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

ECS352	Electronics Devices and Circuits Lab	PCR	3	0	0	3	1.5
Pre-requisites		Course Assessment Methods: Continuous (CT) and end Assessment (EA)					
Basic Electronics (ECC01)		CT+EA					
Course Outcomes	CO#1: Acquire knowledge of identifying analog ICs CO#2: Gain knowledge of designing linear and non-linear analog circuits using transistor CO#3: Develop skills to design amplifier, oscillators and PLL CO#4: Acquire skills to implement analog circuits using breadboard CO#5: Develop acquaintance to use electronic test and measurement instruments.						
List of Experiments	1. Design and set up the BJT common emitter amplifier using voltage divider bias and determine the gain bandwidth product from its frequency response. 2. Design and set up the BJT common collector amplifier using voltage divider bias and determine the gain bandwidth product from its frequency response. 3. Design, setup and plot the frequency response of Common SourceJFET amplifierandobtainthe bandwidth. 4. Design and test a 1 kHz relaxation oscillator using UJT 5. Linear Application of Op-Amp (Inverting amplifier, Non-inverting amplifier). 6. Integrator and Differentiator using IC741 Op-Amp 7. Adder and Subtractor using Op-Amp. 8. Mono-stable Multivibrator using IC 555. 9. Astable Multivibrator using IC 555. 10. Schmitt Trigger Circuit using IC741. 11. IC565 PLL Applications. 12. Voltage Regulator using IC723. 13. RC phase shift & Wien Bridge oscillator using IC741.						
Text Books, and/or reference material	**Reference Materials:** 1. Brian Dean, Introduction to Analog& Digital Circuits Lab Manual, kendall hunt Pub Co, 2018 2. NAVAS, K. A., *Electronics Lab Manual (VOLUME 1 and 2), PHI, Sixth Edition* 3. Departmental Lab Manual						

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	2	-	-	-	-	-	1	1	-	1	2	2	1
CO#2	2	3	3	2	1	-	-	-	1	1	-	1	2	3	1
CO#3	2	3	3	1	1	-	-	-	1	1	-	1	3	2	2
CO#4	1	2	3	2	1	-	-	-	2	1	-	1	3	2	2
CO#5	2	1	2	2	1	1	-	-	3	1	1	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective	Total Number of contact hours = 24				Credit
			Lecture	Tutorial	Practical	Total	

		(PEL)	(L)	(T)	(P)	Hours	
PHS381	Semiconductor Devices Laboratory	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous evaluation (CE) and End Assessment (EA))
Physics Laboratory (PHS51)	CE+EA

Course Outcomes	At the end of the course, a student will be able to: **CO1**. Calculate different characteristic parameter of semiconductor materials. **CO2**. Measure and understand different characteristic of semiconductor devices. **CO3**. Draw the current-voltage characteristics of solar cell for calculation of conversion efficiency.
Topics Covered	**List of Experiments:** 1. To determine the energy bandgap of a semiconductor. 2. Measurement of resistivity of semiconductors by four-probe method at different temperatures. 3. Determination of Hall coefficient of a given semiconductor and its temperature dependence. 4. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnet. 5. Determination of Stefan's constant. 6. Study of p-n junction diode characteristics. 7. Study of Zener diode characteristics and voltage regulator. 8. Determination of photo conversion efficiency of a Solar cell.
Text Books, and/or reference material	**Text Books:** 1. An advanced course in practical physics,Chattapadhyay and Rakshit. 2. Advanced Practical Physics, B. Ghosh and K. G. Mazumdar

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome):

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	2	1	-	-	-	-	1	1	1	-	2	1	-	1
CO#2	3	2	1	-	-	-	-	1	1	1	-	2	1	-	1
CO#3	3	2	1	-	1	1	1	1	1	1	-	2	2	-	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC401	Analog Communication	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))
Network Analysis & Synthesis (ECC 301) Signal and Systems (ECC 303)	The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.
Course Outcomes	At the end of the course, the students will be able to **CO1**: Define and state the elements of communication systems and issues related to transmission of signals through communication channels, radio wave propagation. **CO2**: Explain time and frequency domain equations for all forms of amplitude modulation schemes and corresponding circuits, signals and spectra. **CO3**: Use various analog pulse communication systems and solve problems related to FDM and super heterodyne receiver. **CO4**: Formulate time and frequency domain equations for angle modulation systems and justify related circuits, signals and spectra. **CO5**: Differentiate between various types of noise, and compare noise resistance, noise figure and noise temperature and discuss probability theory, random variables and random processes with related significance in communication systems. **CO6**: Assemble complete analog communication system and formulate the expression of figure of merit for different schemes of modulation.
Topics Covered	1. Introduction: Advantages of Electrical communication; block diagram of an electrical communication system, the fundamental limitation of communication systems. Communication channels and propagation characteristics [**7(L+T)**] 2. Amplitude Modulation and Demodulation: DSB, SSB, VSB. Spectra, Circuits and Systems. [**12(L+T)]** 3. Frequency Modulation and Demodulation: Spectra, Circuits and Systems. [**12(L+T)**] 4. Pulse Modulation: Sampling theorem and its proof. PAM, PWM, PPM [**5(L+T)]** 5. Probability, Random Variable & Random Processes: Mean, Moments, ACF, PSD and WSS, Ergodic and other random processes. [**10(L+T)]** 6. Noise. Noise Figure, Noise Temperature, Performance of Analog communication systems in the presence of Noise. [**10(L+T)**]
Text Books, and/or reference material	**Text Books**: 1. Principle of Communication Systems- H.Taub&D.L.Schilling (TMH). 2. Modern Digital and Analog Communication Systems- B.P.Lathi (Oxford). **Reference Books**: 1. K. Sam Shanmugam, Digital and Analog Communication Systems, Wiley. 2. B. Sklar, Digital Communications, PHI. 3. S. Haykin& M. Moher, Introduction to Analog & Digital Communication, Wiley.

COURSE ARTICULATION MATRIX

Mapping Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	1	2	1	2	-	-	-	2	2	2	3
CO#2	2	2	3	3	2	-	-	-	-	-	-	2	3	2	2
CO#3	1	1	3	1	2	1	-	-	-	-	-	2	2	2	2

CO#4	3	3	2	2	2	-	-	-	-	-	-	2	3	3	3
CO#5	3	3	3	2	3	-	-	-	-	-	-	3	3	3	2
CO#6	2	3	2	3	2	1	2	-	-	-	-	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 56</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC402</td><td>Digital Circuits and Systems</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="2">Electronic Devices and Circuits I (ECC302)
Basic Electronics (ECC01)</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand rules of Boolean Algebra and use it for logic synthesis.
• CO2: Design logic circuits using switches, transistors and integrated circuit building blocks.
• CO3: Understand binary number system and design corresponding arithmetic circuits.
• CO4: Explain and implement A/D and D/A converters.
• CO5: Learn sequential circuit building blocks and implement Finite State Machines.
• CO6: Understand principles of Error Detection and Correction codes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: (L- 1, T-1)
Introduction: Definition of Analog & Digital information. Characteristics of Digital Circuits. Advantages of Digital systems.
Module 2: (L-1 , T- 1)
Boolean Algebra: Introduction – rules of Boolean Algebra, axioms, D'Morgan's theorems
Module 3: (L-2 , T- 1)
Logic Gates: Basic Gates, Universal Gates, Realization of logic gates using switches, Transistors (MOS and BJT) as switch.
Module 4: (L-4 , T-2)
Logic Synthesis: Two level synthesis, SOP/POS forms, canonical forms; Minimization of logical function by - i) Algebraic method, ii)Karnaugh Map method and iii) QuineMccluskey Method.
Module 5: (L-4 , T-2)
Combinational Circuits: Multiplexer, Demultiplexer, Decoder, Encoder, decoder driver, designing using these combinational circuits and their applications.
Module 6: (L-3 , T- 2)
Digital Arithmetic: Number systems, Binary arithmetic, Representing negative numbers – sign-magnitude, 1's complement and 2's complement representations; Arithmatic circuits - Half Adder and Full adder Circuits, multi-bit ripple-carry adder and subtractor circuits. Realization of these circuits using Multiplexers.
Module 7: (L- 6, T-4)
Sequential Circuits: Definition, Elements of sequential circuits - Latches and Registers,</td></tr>
</table>

	Different kinds of flip-flops – R-S, J-K, Master-slave arrangement, D, and T type registers; Finite state machines - Moore and Mealy machines; Typical sequential circuits -counters, shift registers and sequence generator; synchronous and asynchronous circuits. **Module 8: (L-4 , T- 2)** Multivibrator: Definition of different types of Multivibrators, their realization by logic gates, op-amp and transistors. 555 Timer IC. **Module 9: (L-3 , T- 2)** A/D & D/A Converter: Different types of D/A & A/D Converters. **Module 10: (L- 3, T-2)** Codes and Code converters: Gray code, Excess-3 code, BCD Code, BCD to 7-segment decoder: Error Detection and Correction codes - error detection by parity checking, Principle of error correction, Hamming code. **Module 11: (L- 4, T-2)** Different logic families such as RTL, DCTL, DTL, HTL, TTL, ECL, MOS & CMOS logic family their importance and applications.
Text Books, and/or reference material	**Text Books**: 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003. 2. Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2004. **ReferenceBooks**: 1. John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002. 2. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982. 3. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2005. 4. Donald D. Givone, Digital Principles and Design, TMH, 2016. 5. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	2	1	-	-	-	-	-	-	3	3	2	2
CO#2	2	3	3	3	2	-	-	-	-	-	-	2	3	2	1
CO#3	2	3	3	3	3	-	-	-	-	-	-	3	2	3	3
CO#4	2	3	3	3	3	-	-	-	-	-	-	2	3	2	2
CO#5	3	3	3	2	3	-	-	-	-	-	-	3	2	3	2
CO#6	1	2	3	1	1	-	-	-	-	-	-	2	1	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC403	Electromagnetic Theory and Transmission Lines	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					

Mathematics II (MAC02), Engineering Physics (PHC01), Electrical Technology (EEC01)		The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.
Course Outcomes	CO # 1. Understanding electromagnetic theory as a basic building block of electrical communication and enhancing problem solving skills. CO # 2. Enriching historical developments with facts that led to this theory. Emphasis on the fact that we are actually discussing Maxwell's electromagnetic theory. CO # 3. Enhancing theoretical knowledge from a clear viewpoint of phenomenon associated when charges are *at rest*, charges *moving with constant velocity* and during *acceleration/ deceleration* which is results in time harmonic fields. CO # 4. Understanding underlying aspect of radio wave propagation in various media, retarded potentials and concept of radiated waves. CO # 5. Assimilating the transmission line theory as a merger of filed theory and network theory. Imbibing the fundamental aspects of Telegrapher's equation and its essence in the analysis of transmission line parameters.	
Topics Covered	Historical foundations that led to Maxwell's electromagnetic theory **[L-2]** Electrostatics: Coulomb's law and Field Intensity, Gauss's law- Maxwell's Equation, Application of Gauss's Law, Electric Potential. Electrostatic Boundary-Value Problem: Poisson's and Laplace's Equations, Uniqueness Theorem, Resistance and Capacitance, Method of Images. Electric Fields In Material Space: Properties of Materials, Convection and Conduction Currents, Polarization in Dielectrics, Dielectric Constant and Strength, Continuity Equation and Relaxation Time.**[L-10; T-02]** Magnetostatic Fields: Biot-Savart's Law, Ampere's Circuit Law-Maxwell's Equation, Application of Ampere's law, Magnetic Flux Density-Maxwell's Equation, Maxwell's Equations for Static Fields, Magnetic Scalar and Vector Potentials, Derivation of Biot-Savart's Law and Ampere's Law. Magnetic Forces, Materials, and Devices:Forces due to Magnetic Fields, magnetic Torque and Moment, A Magnetic Dipole, Magnetization in Materials, Classification of Materials, Magnetic Boundary Conditions, Inductors and Inductances, Magnetic Energy, Magnetic Circuits, Force on Magnetic Materials, Analogy between Electrostatics and Magnetostatics **[L-8; T-02]** Time Varying Fields, Waves, and Applications: Maxwell's Equations:Faraday's law, Transformer and Motional EMFs, Displacement Current, Maxwell's Equations in Final Forms, Time-Varying Potentials, Time-harmonic Fields.**[L-8; T-02]** Electromagnetic Wave Propagation: Wave Propagation in Lossy Dielectrics, Plane Waves in Lossless Dielectrics, Plane Waves in Free Space, Plane Waves in Good Conductors, Skin depth, Wave Polarization, Power and the Poynting Vector, Reflection of a Plane Wave at Oblique Incidence.**[L-8; T-02]** Transmission Lines: Introduction to different types of planar and non-planar guided media, Transmission line parameters, Telegrapher's equation, Input impedance, SWR, Power flow in transmission lines, Introduction to parallel plate and hollow metallic waveguides. **[L-10; T-02]**	
Text Books, and/or reference material	**Text Book:** [1] Matthew O H Sadiku, *Principles of Electromagnetics*, 4/e, Oxford University Press. **Reference books:** [1] E. C. Jordan and K. G. Balmain, *Electromagnetic Waves and Radiating Systems*, 2/e, PHI (Addison Wesley). [2] J. D. Ryder, "Networks, Lines and Fields", Pearson [3] David. M. Pozar, *Microwave Engineering*, 2/e, 1998 (John Wiley & Sons). [4] S. Ramo, J. R. Whinnery, and T. Van Duzer, *Fields and Waves in Communication Electronics*, 3/e, John Wiley and Sons, 1994. [5] David K. Cheng, *Field and Wave Electromagnetics*, 2/e, 1989. [6] R. E. Collin, "Foundations for Microwave Engineering", John Wiley	

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2
CO#4	1	2	1	1	1	3	2	1	2	1	1	1	3	3	2
CO#5	2	3	1	2	1	1	1	1	2	1	1	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 44				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC431	Control Systems	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods: Continuous (CT), Mid-Term (MT), End Assessment (EA)
Engineering Physics (PHC01), Signals and Systems (ECC303)	The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.

Course Outcomes	At the end of the course students will be able to: **CO1**: Understand the basic objectives of control system design. **CO2**: Derive input-output relationship of systems based on their mathematical modeling governed by basic laws of physics. **CO3**: Justify stability of systems based on their transfer functions, time domain and frequency domain specifications. **CO4**: Develop concepts on root pattern with variable gains and comment on the stability. **CO5**: Determine the stability of closed-loop system based on open loop frequency response. **CO6**: Design controllers so as to meet design specifications both in time as well as frequency domain. **CO7**: Realize the controller both in software simulation through MATLAB coding as well as in real-time environment.
Topics Covered	**Introduction to control systems**:[4L] Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. **Mathematical Models of Physical Systems**:[4L] Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason's Gain formula. **Introduction to State Variable Approach**:[4L] Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix. **Representation of Control Components**: [2L] Electrical components, Mechanical components, Electromechanical Components. **Time domain analysis and design specification of linear systems**:[8L] Standard signals, Transient response and S-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of

	adding poles and zeros to transfer functions, P, PI, PD and PID controllers. **Concepts of Stability and Algebra Criterion**:[4L] Concept of stability, characteristic equation necessary conditions for stability, Routh-Hurwitz stability criteria. **Root Locus Technique**:[4L] The root locus concept, construction of Root Loci, Important properties parameters design byRoot locus method, Root-locus Plots with MATLAB. **Frequency Response Analysis and Stability Studies in Frequency Domain**:[10L] frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, Conditionally stable system, M and N loci on complex and gain phase plan MATLAB tools and case studies. **Design and Compensation Technique**:[4L] Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and S-plane design techniques,Example of control systems. Design with MATLAB.
Text Books, and/or reference material	**Text Books**: 1. J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic control system, John Wiley & Sons **Reference Books**: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	3	2	1	1	-	-	-	-	2	3	2	2
CO#2	3	3	2	3	2	-	-	-	-	-	-	1	3	2	2
CO#3	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#4	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#5	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#6	3	2	3	3	3	1	1	1	-	-	-	2	3	3	2
CO#7	3	2	3	3	3	1	-	1	-	-	-	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 24				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS451	Analog Communication Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods Continuous (CT) and end assessment (EA)					
Network Analysis & Synthesis (ECC301)		CT+EA					

Course Outcomes	CO1: Understand the fundamentals to explain the functionality of modulation and demodulation. CO2: Analyze the concepts, write and simulate the concepts of AM and AM Demodulation process in Communication. CO3: Know FM and FM-Demodulation process in communication. CO4: Discriminate the AM and FM functionalities. Interpret with various angle modulation and demodulation systems. CO5: Create the simulation environments in PAM, PWM, PPM and verification of circuit and waveform in software platform.
Labs Conducted.	12. To generate amplitude modulated wave and determine the percentage modulation. 13. To demodulate the modulated wave using envelope detector. 14. To observe the output waveform of each block of super heterodyne receiver. 15. To measure modulation index in FM and show the demodulated waveform. 16. To perform pulse amplitude modulation and demodulation 17. To perform pulse position modulation and demodulation 18. To perform pulse width modulation and demodulation 19. To observe DSB, DSB-SC, SSB waveforms in time domain and frequency domain in MATLAB platform. 20. To observe DSB, DSB-SC, SSB waveform in time domain and frequency domain in MATLAB platform. 21. To design transmitter and receiver circuit for amplitude modulation using discrete components. 22. To design transmitter and receiver circuit for frequency modulation using discrete components.
Text Books, and/or reference material	**Text Books**: 3. Morden Analog & Digital Communication System- B.P. Lathi 4. Digital and Analog Communication Systems– K. Sam Shanmugam. 5. Principle of Communication Systems- Taub& Schilling. **Reference Materials**: 6. Lab instruction manual 7. Instruction manuals provided by manufacturer

COURSE ARTICULATION MATRIX

Mapping ofCourse Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	-	-	-	-	-	1	1	1	2	2	2
CO#2	3	3	2	2	1	-	-	-	-	1	-	-	2	3	2
CO#3	3	3	2	2	1	-	-	-	-	1	-	-	2	2	2
CO#4	3	2	-	1	-	-	-	-	-	-	-	-	2	1	1
CO#5	2	2	2	3	3	-	-	-	-	1	1	1	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 30</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS452</td><td>Digital Circuits and Systems Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
Continuous (CT), End Assessment (EA)</td></tr>
<tr><td colspan="3">Basic Electronics (ECC01)</td><td colspan="5">The assessment methods comprise of quizzes and multiple choice type questions based on laboratory work and developing experimental set ups.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After conducting the laboratory experiments student will be able to:
CO1: Understand digital circuits as basic building blocks of electrical communication, control system with enhanced problem solving skills.
CO2: Enrich knowledge of historical developments with facts that led to this theory leading to Integrated Circuits domain.
CO3: Design and develop complex digital circuits for electronics appliances.
CO4: Develop subsystems for the design of digital computers.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Experiment :1
1.1 Design of half adder and half subtractor circuit using nand gates only.
1.2 Design of 5-bit even / odd parity checker circuit using xor gate.
Experiment: 2
2.1Realization of multiplexer as universal logic gate.
2.2 Design full adder and full subtractor circuit using4:1 multiplexer
Experiment: 3
3.1 Realising a bcd to decimal decoder circuit using decoder driver and seven segment led display.
3.2 Verifying the function table of 8 to 3 line priority encoder.
Experiment: 4
4.1 Design of four bit one's complement binary adder / subtractor circuit.
4.2 Design of four bit two's complement binary adder / subtractor circuit.
4.3Design of four and five bit digital magnitude comparator.
Experiment: 5
5.1Verification of excitation table of J-K flipflop.
5.2 Verification of excitation table of D flipflop.
5.3Design of T type flip flop from D type flipflop.
Experiment: 6
6.1 Design of asychronous up counter using J-K flipflop.
6.2Design of sychronous up counter using D flipflop.
Experiment: 7
7.1 Study of asynchronous decade counter IC, 7490 in different modes.
7.2 Study of asynchronous binary counter or mod 16 counter IC 7493 in different modes.
Experiment: 8
8.1Study of synchronous decade counter IC 74160 in different modes.
8.2Study of synchronous up / down counter IC 74192.
Experiment: 9
9.1Study of 64-bit read / write memory.
9.2Study of 4-bit universal shift register.
Experiment: 10
10.1Study of 4-bit arithmatic logic unit.</td></tr>
</table>

Text Books, and/or reference material	**Text Book**: 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003. **Reference Books**: 1. John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002. 2. Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2004. 3. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982. 4. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2005 5. Donald D. Givone, Digital Principles and Design, TMH, 2016. 6. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	-	-	-	-	-	1	1	1	2	2	2
CO#2	3	3	2	2	1	-	-	-	-	1	-	-	2	3	2
CO#3	3	3	2	2	1	-	-	-	-	1	-	-	2	2	2
CO#4	3	2	-	1	-	-	-	-	-	-	-	-	2	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 30				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES481	Control Systems Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods Continuous evaluation (CE) and End Assessment (EA)					
ECC303(Signals and Systems)		CE+EA					
Course Outcomes	• CO1: To understand the dynamic behaviour of real-time systems. • CO2: To simulate physical systems in real-time environment. • CO3: To design control system to improve the performance characteristics of real-time systems. • CO4: To determine the parameters and transfer function of physical systems from real-time experimentation. • CO5: To get acquainted with MATLAB programming, MATLAB-SIMULINK in order to simulate, analyze and design of control system design for different plants under consideration.						
Topics Covered	1. DC Servo Speed Control System 2. DC Servo Position Control System 3. Temperature Control System 4. Linear System Simulator 5. Lead and Lag Network 6. P, PI and PID controller 7. Study of Different real-time systems through Simulation in MATLAB 8. PID Design Method for DC motor Speed Control using MATLAB						

	9. Root Locus Design Method for DC motor Speed Control using MATLAB 10. DC motor Speed Control Based on Frequency Response using MATLAB
Text Books, and/or reference material	**Text Books:** 1. J. Nagrath and M Gopal, *Control system Engineering*, New Age International Publishers. 2. K. Ogata, *Modern Control Engineering*, Prentice Hall **Reference Books:** 1. B. Shahian, M. Hassul, *Control System Design using MATLAB*, Prentice Hall. 2. Laboratory instruction manuals.

COURSE ARTICULATION MATRIX

Mapping Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome(PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	3	2	1	1	-	-	-	-	2	3	2	2
CO#2	3	3	2	3	2	-	-	-	-	-	-	1	3	2	2
CO#3	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#4	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#5	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 56</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC501</td><td>Digital Communication</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods:
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="2">Analog Communication (ECC401)</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">

CO1:Acquire idea about analog to digital conversion.
CO2:Understand simultaneous transmission of digital signals.
CO3:Learn communication techniques for wired channels.
CO4:Analyze and mitigate interference in wired channels.
CO5:Learn communication techniques for wireless channels.
CO6:Differentiate between different coding and modulation strategies.
CO7: Understand the basic concepts of Information theory, Source and Channel Coding, Channel Capacity and relation among them
CO8 : Learn basics of random process, modeling and analysis of systems with random signal
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Introduction to digital communication [3 hrs.]

Module 2:Review of random process [5 hrs.]
Basic definition, Stationarity, Ergodicity, autocorrelation, cross correlation, power spectral density, Response of Linear systems to Random inputs, Gaussian process, Narrow band noise, Rayleigh pdf
Module 3:Waveform coding [12 hrs.]
PCM – generation, regenerative transmission, detection; Linear quantization, quantization noise, non-uniform quantization, companding; Channel noise and error probability; TDM, PCM-TDM hierarchy; Delta modulation, adaptive delta modulation.
Module 4:Baseband transmission [12 hrs.]
Line coding – types, criterions for choosing a line code, power spectra; ISI, Nyquist criterion for zero ISI, eye pattern; Mitigation of ISI – raised cosine filtering, equalization. Matched filter.
Module 5: Passband transmission [12 hrs.]
Relation between amplitude, time period, and energy, characterization of noise, signal space representation; Binary modulations – ASK, PSK, FSK. QPSK, MSK; Generation, detection (coherent/ non-coherent), power spectra, and error probability of digital CW modulations.
Module 6: Information theory and coding [12 hrs.]
Measure of information, Entropy, Joint and Conditional entropy, Self and Mutual Information, Channel capacity and Shannon's law; Coding for compression –Source coding theorem, variable length coding, Huffman coding; Coding for error correction – Noisy coding theorem, parity checking, Hamming code, Generator and Parity Check Matrices, Linear block codes.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Introduction to Analog & Digital Communications - S. Haykin, M. Moher.
2. Digital Communication - J. G. Proakis, M. Salehi.
Reference Books:</td></tr>
</table>

	1. Digital Communications - S. Haykin. 2. Modern Digital and Analog Communication Systems - B. P. Lathi, Z. Ding. 3. A First course in Digital Communications - H. H. Nguyen, E. Shwedyk. 4. Principles of Communications - R. E. Ziemer, W. H. Tranter. 5. Principles of Communication Systems - H. Taub and D. L. Schilling. 6. Digital and Analog Communication Systems - K. S. Shanmugan. 7. Digital and Analog Communication Systems - L. W. Couch. 8. Digital Communications - B. Sklar. 9. Theory and Design of Digital Communication Systems - T. T. Ha.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	3	2	2	3	1	1	1	1	1	1	3	2	2
CO#2	2	2	2	3	2	3	2	1	1	1	2	1	2	3	3
CO#3	3	2	2	2	3	2	2	1	1	1	1	1	2	3	2
CO#4	2	3	3	3	3	2	1	1	1	2	1	2	3	2	2
CO#5	3	2	2	2	3	2	2	1	1	1	1	1	2	3	2
CO#6	2	3	2	3	2	2	1	1	1	2	2	1	3	2	3
CO#7	3	3	3	3	2	2	1	1	1	1	1	1	3	2	3
CO#8	3	3	3	3	2	2	1	1	1	1	1	1	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC502	Microwave Engineering	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Electromagnetic Theory and Transmission lines (ECC403)		CT+MT+EA					
Course Outcomes	**CO1:** Understand behaviour of transmission lines and waveguides, gain complete knowledge about Microwave components. **CO2:** Analyze and explain the characteristics of microwave passive components. **CO3:** Analyze and explain the characteristics of microwave active components and circuits. **CO4:** Acquire knowledge about the measurements at microwave frequencies.						

Topics Covered	**Module – I:** (L – 2; T -1) **Wave Propagation in Unbounded and Bounded Media**: Classification of Waves - TEM Waves, TE Waves and TM Waves, Parallel Plate Waveguide – TEM modes, TE modes, and TM modes; Solution techniques for modes and boundary conditions, Wave Velocities - Phase Velocity, Group Velocity, Energy-Flow Velocity. [T1] **Module – II:** (L – 6; T -3) **Waveguides:** General properties of rectangular and circular waveguides, Solution of wave equation – TE Modes, TM Modes, power transmission, power losses, excitation of modes, characteristics of standard rectangular waveguides. Solution of wave equation – TE Modes, TM Modes and TEM modes in circular waveguide, power transmission, power losses, excitation of modes, characteristics of standard circular waveguide [T1, T2] **Module – III:** (L – 2) **Dielectric waveguide and surface wave:** Surface Waves on a Grounded Dielectric Slab – TM Modes, TE – Modes. [T1, T2] **Module – IV:** (L – 2; T -1) **Impedance Matching:** Concept of impedance in guided waves, Smith-chart and its use, Impedance matching techniques - quarter wave transformer, single stub, double stub. [T2 and T3] **Module – V:** (L – 3; T -1) **Microwave Resonators:** Rectangular Waveguide Cavity resonators - Resonant Frequency, Q – factor; Circular Waveguide Cavity resonators - Resonant Frequency, Q – factor; Dielectric Resonators - Resonant Frequency; Excitation of Resonators. [T1, T2] **Module – VI:** (L – 3; T -1) **Microwave Network Theory:** Equivalent Voltages and Currents, The Concept of Impedance, Impedance and Admittance Matrices, Scattering parameters, Signal Flow Graphs, ABCD Matrix [T1] **Module – VII:** (L – 3; T -1) **Microwave Passive Components:** E-plane Tee, H-plane Tee, Magic Tee, Hybrid ring, circulator, isolators, Attenuator, Phase-shifter, directional coupler, slotted section, windows (Capacitive and Inductive), Irises. [T1, T2] **Module –VIII:** (L – 4; T -2) **Microwave Solid-state Devices:** Solid state microwave sources based on IMPATT diode, TRAPATT Diode, Gunn diode, Tunnel diode, Detectors and mixers: PIN diode, Schottky Diode, Varactor, diode, Step recovery diode. [T2] **Module – IX:** (L – 3; T -1) **Microwave Vaccum Tube Devices:** Microwave Amplifiers: Klystron amplifiers, TWT – space TWT and Helix TWT, Magnetron. [T2] **Module – X:** (L – 2; T -1) **Microwave Measurement and Communication:** Measurement of microwave power, impedance, standing wave, frequency and phase-shift. Microwave antenna, Line of sight propagation, microwave links, satellite communication. [T3]
Text Books, and/or reference material	**Text Books**: T1. D M Pozar, “Microwave Engineering”, Fifth Edition, Wiley India, New Delhi, India, 2005. T2. Liao, Samuel Y., “Microwave devices and circuits 3/E”, Pearson Education India, 1989. T3. Collin, Robert E., “Foundations for microwave engineering 2/E”, John Wiley & Sons, 2007. **Reference Books**: R1. Radmanesh, Matthew M., “Radio frequency and microwave electronics illustrated”, New Jersey: Prentice Hall, 2001.

	R2. CA Balanis, Advanced Electromagnetic Engineering, John Wiley, New York, 2003. R3. Cheng, David Keun, "Field and wave electromagnetics", Pearson Education India, 1989.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	3	2	1	1	1	1	1	1	-	-	-	1	3	1	2
CO#2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	2
CO#3	3	2	2	2	2	1	-	1	-	-	-	1	2	2	3
CO#4	3	2	1	1	1	1	1	1	-	-	-	1	3	2	3

Correlation levels 1, 2 or 3 as defined above:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and "-" if there is no correlation.

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC503	Microprocessors and Microcontrollers	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-semester assessment (MA) and End Assessment (EA)):					
Digital Circuits and Systems (ECC402)		CT+MT+EA					
Course Outcomes	At the end of the course, a student will be able to: • **CO1 Describe** the fundamental operations and internal architectures of microprocessors and Microcontroller's as well as **identify** the peripherals to be used for the given microprocessor and Microcontroller based problems. • **CO2 Understand** the performance of Microprocessor (8085 & 8086) and Microcontroller based systems and **select** appropriate platform to meet specified requirements. • **CO3 Apply** the knowledge of Microprocessors, Microcontrollers and peripheral devicesand demonstrate the programming proficiency using the various instruction codes of the target microprocessor and microcontroller. • **CO4 Analyze** different problems on microprocessors and microcontrollers and write appropriate assembly language programs. • **CO5 Evaluate** the machine codes to providesolutions to the real-world problems. • **CO6 Design** necessary I/O and Memory interfacing circuitry to communicate Microprocessor and Microcontroller with external devices.						
Topics Covered	**Module – I:** (L – 6; T -2) **Introduction to Microprocessor:** Basic computer architecture, stored program computer concept; Evolution of Microprocessors, 8085 Architecture, drawbacks and Instruction sets and programming with 8085.[CO#1, 2, 3, 4, 6]; [T1] **Module – II:** (L –7; T - 3) **Microprocessor 8086/8088:** 8086: Architecture-Functional diagram, Register organization, signal description, Memory Segmentation, physical memory organization, general bus						

	operation, I/O addressing capability, special purpose activities, Minimum mode, maximum mode of 8086 system and timings, the processor 8088, Programming Model, machine language instruction formats, addressing modes, instruction set, assembler directives and operators. Macros and Simple Programs involving Logical, Branch and Call Instructions, Sorting, String Manipulations. [CO#1, 2, 3, 4, 6]; [T1, T2, R1, R2] **Module – III:** (L – 5; T - 2) **Programming with 8086:** Machine level programs, programming with an assembler, Assembly language programs, and introduction to stack, stack structure of 8086/8088, interrupts and interrupt service routines, interrupt cycle of 8086, non-mask able interrupt and mask able interrupts, interrupt programming, The coprocessor 8087. [CO# 3, 4, 5];[T2, R1, R2] **Module – IV:** (L – 6; T - 2) **I/O And Memory Interface:** LCD, Keyboard, External Memory RAM, ROM Interface, ADC, DAC Interface to 8051. Serial Communication and Bus Interface: Serial Communication Standards, Serial Data Transfer Scheme, On board Communication Interfaces-I2C Bus, SPI Bus, UART; External Communication Interfaces-RS232,USB. [CO#1, 3, 6]; [T2, R2] **Module – V:** (L – 6; T - 2) Programmable Peripheral Interfacing: Description and programming of Intel 8255, 8257, 8155, 8253, 8251 and 8259A, 8279A etc.[CO#1, 3, 6];[T2, R1] **Module – VI:** (L – 1) **Development of Processors:** 80186, 80386, RISC.[CO# 1, 5]; [T2, R2] **Module – VII**; (L – 5; T - 2) **Microcontrollers:** Introduction, Overview of 8051 Microcontroller, Architecture, I/O Ports, Memory Organization, Addressing Modes and Instruction set of 8051. 8051 Real Time Control: Programming Timer Interrupts, Programming External Hardware Interrupts, Programming the Serial Communication Interrupts, Programming 8051 Timers and Counters, assembly language programming tools.[CO#1, 3, 4, 6]; [T3, R3] **Module – VIII:** (L – 2) **PIC Microcontrollers:** Introduction, Architecture, ALU, Program memory, register, Instruction Interrupts, Peripherals. [CO# 1, 3, 6]; [T4, R4] **Module –IX:** (L – 4, T -1) **Arduino Microcontroller Board and ARM:** Introduction, Introducing the Arduino Board Installing and familiarizing the Arduino IDE, Connection diagram examples and program code. ARM Special Features and applications, Architecture, Registers, processor modes, instructions, stack organization, ARM I/O System, memory interface, pipeline organization, simple example of ARM based embedded system.[3, 4, 6]; [T5, R5-R7]
Text Books, and/or reference material	**Text Books** 1. Microprocessor, Architecture, Programming and Applications with Microprocessor 8085;Author: Ramesh S. Gaonkar (5th Edition); Publisher – Prentice Hall **(Modules I)** 2. Advanced Microprocessors and Peripherals, Authors: A. K. Ray, K. M. Bhurchandi; Publisher - Tata McGraw Hill. **(Modules I – VI)** 3. The 8051 Microcontroller and Embedded Systems by Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay, Pearson Education. **(Modules VII)** 4. PIC Microcontrollers; Author - M. Bates; Publisher - Newnes. **(Module VIII)** 5. The AVR Microcontroller and Embedded Systems Using Assembly and C: Using Arduino Uno and Atmel Studio; *Author* - SepehrNaimi and SarmadNaimi, Muhammad Ali Mazidi; *Publisher* – Majidi and Naini**(Modules IX)** **References:** 1. Microprocessors and Interfacing: Programming and Hardware; Authors: Douglas V. HallPublisher - Tata McGraw Hill 2. The Intel Microprocessors – Architecture, Programming and Interfacing; Authors: Barry B. Brey; Publisher: Pearson Education

	3. The 8051 Microcontroller, Kenneth. J. Ayala, Cengage Learning, 3rd Ed. 4. The 8051 Microcontroller: A Systems Approach; Authors: M.A. Mazidi, R.D. McKinlay, J.G. Mazidi; Publisher- Pearson. 5. Embedded microcontroller and processor design; Authors: G. Osborn; Publisher: Pearson 6. *Arduino Cookbook;* Authors: Michael Margolis, Publisher: O'Reilly Media, Inc, 7. W.A. Smith, "ARM Microcontroller Interfacing: Hardware and Software, Eketor, 2010.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome):

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	3	3	1	1	1	1	-	-	-	2	2	2	1
CO#2	3	2	2	1	1	1	-	1	-	-	-	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	-	-	-	1	3	3	2
CO#4	1	2	3	2	1	1	-	1	-	-	-	1	3	3	2
CO#5	2	3	1	2	1	2	2	1	-	-	-	1	2	3	2
CO#6	3	2	3	2	1	-	-	-	-	-	-	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC504	Electronic Devices and Circuits-II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods: ((Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Electronic Devices and Circuits I (ECC302), Basic Electronics (ECC01), Network Analysis and Synthesis (ECC301)		Assignments, Mid Semester and End Semester Examination					
Course Outcomes	At the end of this course students will be able to: CO # 1. Understand the fundamental principles of amplifiers and oscillators. CO # 2. Able to design Power Amplifiers CO # 3. Become familiar with the design of wave shaping circuits. CO # 4. Able to design regulated power supply circuits CO # 5. To be able to make use of the recently developed electronic devices in solving the present day complex electronic systems.						
Topics Covered	**1. Output Stages and Power Amplifiers (6L+2T)** Classification of Output Stages; Power Amplifier, Class A, Class B, Class AB and Class C amplifiers, Biasing the Class AB Stage; Push-Pull Amplifiers – Transformer Coupled and Complementary symmetry configurations; Tuned Amplifiers, Class – D amplifiers, Power Transistors–Power B.J.T'S Power MOSFETs, Power amplifier designing, Thermal analysis and						

	Heat sinks; **2. Feedback Amplifiers And Oscillators (9L+2T)** Introduction to Feedback, Basic Feedback Concepts, Ideal Close−Loop Gain, Advantages of negative feedback, Gain Sensitivity, Bandwidth Extension, Noise Sensitivity, Reduction of Non−Linear Distortion; Feedback Topologies, Series−Shunt, Shunt−Series, Series−Series, Shunt−Shunt Configurations, The Stability Problem, Bode Plots, One−Pole, Two−Pole and Three−Pole Amplifiers, Nyquist Stability Criterion, Phase and Gain Margins, Frequency Compensation Basic Theory, Closed Loop Frequency Response, Miller Compensation; Positive feedback, Condition for oscillations, phase shift, Wien bridge, Hartley, Colpitts and Crystal oscillators. Phase shift oscillators, Wien bridge oscillators, Tuned circuit oscillators, **3. Differential Amplifier (6L+2T)** Differential amplifier – Common mode and Difference mode analysis – FET input stages – Amplifier biasing: current source and Current mirror – Gain and frequency response – Neutralization methods. **4. Operational Amplifiers (7L+2T)** Basics of operational amplifiers, open loop and closed loop response, Application of op−amps, viz, inverting and non inverting amplifiers, voltage follower, adder, substractor, differentiator and integrator, Comparators, clippers andclampers, Schmitt triggers, precision rectifiers, peak detectors, Log and Antilog amplifiers, gyrator, Current to voltage and voltage to current converters, Instrumentation and isolation amplifiers, transducer Bridge amplifiers. General op−amp circuit design and detailed circuit description. **5. Signal Generator and Waveform-Shaping Circuits (6L+1T)** Op Amp-RC Oscillator Circuits; LC and Crystal Oscillators; Generation of Square and Triangular Waveforms Using AstableMultivibrators; Integrated Circuit Timers; **6. Power Supplies, Breakdown Diodes, and Voltage Regulators (6L+2T)** Unregulated Power Supply; Basics of voltage regulators, Performance specifications; linear regulators, Current Limiting; Integrated Circuit Voltage Regulators, IC 78XX, 79XX, LM317, IC 723; Voltage references - Bandgap Voltage Reference; switching regulators and monolithic switching regulators, DC to DC convertors. **7. Special-purpose Devices (5L)** Schottky barrier diodes, , MIS diode, heterojunctions devices, Tunnel Diode (with the help of Energy Band Diagram), Varactor Diode, UJT, SCR.
Text Books, and/or reference material	**Text Books:** J. Millman, C.C.Halkias, "Electronic Devices and Circuits" Thomas L. Floyd, "Electronic Devices", 8th Edition, Pearson Education Inc., 2007 **Reference Books:** Mohammad Rashid, "Electronic Devices and Circuits" Cengage Learing, 2013 Schilling and Belove, "Electronic Circuits: Discrete and Integrated",McGraw-Hill , 3rd Ed. Robert Boylestad and Louis Nashelsky, " Electronic Device and Circuit Theory", PHI; 9th Edition, 2007 A.S. Sedra and K.C. Smith, "Microelectronic Circuits", 6th Edition, Oxford Univ. Press, 2006 David A. Bell, "Electronic Devices and Circuits" 5 Ed, Oxford.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#2	2	2	3	2	3	-	1	-	-	-	-	2	2	3	2
CO#3	2	2	3	2	1	-	-	-	-	-	-	2	3	2	2

Department of Electronics and Communication Engineering

CO#4	2	3	2	3	3	2	1	1	-	-	-	2	3	3	2
CO#5	2	3	3	3	2	1	1	1	-	-	2	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 24				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS551	Digital Communication Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Analog Communication Laboratory (ECS451)		CE+EA					
Course Outcomes	• **CO1:Acquire** idea about analog to digital conversion. • **CO2:Understand** simultaneous transmission of digital signals. • **CO3:Learn** communication techniques for wired channels. • **CO4:Analyze** and mitigate interference in wired channels. • **CO5:Learn** communication techniques for wireless channels. • **CO6:Differentiate** between different coding and modulation strategies.						
Topics Covered	List of experiments 1. Pulse code modulation (PCM) - Generation and detection 2. Delta modulation (DM) - Generation and detection 3. Adaptive delta modulation (ADM) - Generation and detection 4. Sampling and signal reconstruction 5. Time division multiplexing (TDM) 6. Line coding 7. Amplitude shift keying (ASK) - Generation and detection 8. Phase shift keying (PSK) - Generation and detection 9. Frequency shift keying (FSK) - Generation and detection						
Text Books, and/or reference material	**Text Books/Reference Manual**: 1. Introduction to Analog & Digital Communications - S. Haykin, M. Moher. 2. Digital Communication - J. G. Proakis, M.Salehi. 3. Lab. instruction manual.						

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	3	2	-	-	-	-	2	1	1	1	3	2	2
CO#2	2	2	2	3	-	-	-	-	2	1	-	1	2	3	3
CO#3	3	2	2	2	3	-	-	-	1	1	-	1	2	3	2
CO#4	3	3	2	2	-	-	-	-	1	2	-	2	3	2	2
CO#5	3	3	2	2	-	-	-	-	1	1	-	1	2	3	2
CO#6	3	3	1	2	-	-	-	-	1	2	-	1	3	2	3

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 18</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS552</td><td>Microwave Engineering Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods
(Continuous (CT), and end assessment (EA))</td></tr>
<tr><td colspan="3">Electromagnetic Theory and Transmission Lines (ECC403)</td><td colspan="5">Day to day evaluation during the laboratory session and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After successful completion of this course, the students will be able to
CO#1: Realize the characteristics of Microwave sources and passive components.
CO#2: Use microwave test bench to measure Frequency, wavelength and VSWR.
CO#3:Analyze the characteristics of microwave sources.
CO#4:Arrange complete microwave test bench to observe the characteristics of different microwave components.</td></tr>
<tr><td>List of Experiments</td><td colspan="7">1. Study of the characteristics of Gunn Diode and Gunn Oscillator
2. Study of the characteristics of magic-Tee and directional coupler
3. Measurement of source frequency, guided wavelength and VSWR using microwave test bench
4. Measurement of input impedance with unknown load.
5. Use of Microwave Power meter
6. Study of reflex-klystron characteristics
A. Measurement of output power using power meter
B. Plot of beam voltage vsrepeller voltage.
C. Plot of frequency vs. Repeller voltage.
D. Plot of frequency vs. Output power.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
[T1] Sisodia and Raghuvangshi, Microwave Laboratory Manual, New Age International.
[T2]Lab. Instruction manual.
Reference Books:
[R1] Balanis, Antenna Theory and Design, Wiley Publications
[R2] John D. Krauss, Antennas for all Applications, TMH.
[R3]Edward C.Jordan and Keith G.Balmain” Electromagnetic Waves and Radiating Systems” Prentice Hall of India.</td></tr>
</table>

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	1	2	1	-	-	-	-	1	1	-	1	2	2	1
CO#2	3	2	2	-	-	-	-	-	2	1	-	1	2	1	1
CO#3	3	1	2	2	1	-	-	-	-	1	-	1	3	3	2
CO#4	3	2	1	1	-	-	-	-	1	1	-	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 30</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS553</td><td>Microprocessors and Microcontrollers Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods
(Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Digital Circuits and Systems (ECC402)</td><td colspan="5">Day to day evaluation during the laboratory session and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of thisseasonal course, a student will be able to:
• Recognize the different parts of Microprocessors, Microcontrollers and peripheral devices.
• Interpret methodologies to be adopted for the specified problems on Microprocessors and Microcontrollers.
• Apply appropriate instruction codes to develop the program for Arithmetic, logical, data transfer and copying operations as well as data communication to external devices.
• Analyze requirements of experimental setup of using Microprocessor and Microcontroller.
• Construct the necessary interfacing circuitry to communicate Microprocessor and Microcontroller with the external devices.</td></tr>
<tr><td>List of Experiments</td><td colspan="7">Part A: Programming using Microprocessor 8085 Kit
1. Perform the following arithmetic operations
a) Addition and subtraction of two 8 bit nos.
b) Addition and subtraction of two 16 bit nos.
c) Multiplication and division of two 8 bit nos.
2. Determination of factorial of a given number.
3. Display Fibonacci series.
4. Determination of the smallest and largest element of an array.
5. Sorting the data array as follows
a) Ascending order.
b)Descending order.
6. Generation of the following waveforms
a) Triangular.
b) Square.
7. Interfacing with stepper Motor.
Part B: Programing using Microprocessor 8086 Kit and simulator
1. Perform the following arithmetic operations of two 16 bit nos.
a) Addition.
b) Subtraction.
c) Multiplication.
d) Division.
2. Determination of factorial of a given number.
3. Move contents of an array from one memory location to another location.
4. Perform the following conversions of the number system
a) Convert a given decimal no. to hexadecimal.
b) Convert a hexadecimal no.</td></tr>
</table>

	5. Separation of odd and even nos. 6. Determination of the sum of n consecutive nos. of an array. 7. Sorting the elements of an array as follows a) Ascending order. b) Descending order. 8. Reverse a given string and verify whether it is a palindrome or not. 9. Interfacing with stepper Motor. 10. Interfacing with 7 segment display. 11. Interfacing with keyboard controller. **Part C: Programing using Microcontroller 8051 Kit and simulator** 1. Perform the following arithmetic operations of two 16 bit nos. a) Addition. b) Subtraction. c) Multiplication. d) Division. 2. Exchange the contents of two memory locations. 3. Determination of the sum of first n natural nos. using 8051 Microcontroller. 4. Check whether given number is palindrome or not. 5. Determination of the largest and smallest no. of a data array. 6. Sorting the data array as follows a) Ascending order. b) Descending order. 7. Perform the following conversions of the number system a) BCD to ASCII. b) ASCII to Decimal. c) Decimal to ASCII. 8. Generation of 1 second delay continuously using on-chip timer. 9. Interfacing with stepper motor. 10. Generation of square waveform. 11. Interfacing with LCD. **Part D: Programming on ARDUINO Microcontroller Board** 1. Blink the on board LED. 2. Generation of square waveform. 3. Interfacing with LCD.
Text Books, and/or reference material	**Text Books** 1. Lab. instruction manual and operation manuals supplied by the manufacturers. 2. Microprocessor Architecture, Programming and Applications with the 8085; Authors: R. Gaonkar; Publisher -, Prentice Hall. 3. Advanced Microprocessors and Peripherals, Authors: A. K. Ray, K. M. Bhurchandi; Publisher Microprocessors and Interfacing: Programming and Hardware; Authors: Douglas V. HallPublisher - Tata McGraw Hill. 4. The 8051 Microcontroller and Embedded Systems by Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay, Pearson Education. 5. The 8051 Microcontroller: A Systems Approach; Authors: M.A. Mazidi, R.D. McKinlay, J.G. Mazidi; Publisher- Pearson.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO

CO	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#1	#2	#3
CO#1	2	-	-	-	1	-	-	-	-	-	-	1	2	1	1
CO#2	3	-	3	-	2	1	-	-	1	1	-	1	2	1	1
CO#3	3	1	2	1	2	1	-	-	1	1	-	1	1	3	1
CO#4	3	1	2	1	2	1	-	-	1	1	-	1	1	3	1
CO#5	3	3	3	1	1	-	-	-	-	1	-	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	Economics and Management Accounting	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• **CO1**:To make budding engineers aware of various aspects of micro economic theories which will help engineers to take decision in the organization • **CO2**:To impart knowledge on various tools and techniques applied in economics by the executives of an organization • **CO3**:To make potential engineers aware of macro economics variables affecting business • **CO4**:To impart knowledge on basics of accounting procedure and functional knowledge required in the area of accounting decision making						
Topics Covered	Group A: Microeconomics Unit 1: *Economics: Basic Concepts (2)* (a) Introduction to study of Economics and Microeconomics for Engineers (b) Markets and Prices: definition, extent (c) Demand and Supply – market mechanism – market equilibrium – elasticity of demand and supply – market equilibrium – short run versus long run (d) Understanding the effects of changing market conditions (e) Effects of government intervention in market – price control(2L) Unit 2: *Theory of Consumer Behaviour* (a) Utility – ordinal utility – cardinal utility – constructing a utility function – some examples of utility function – Marginal Utility (MU) (b) Consumer preferences – assumptions about preferences – indifference curves – perfect substitutes, perfect compliments – the marginal rate of substitution (MRS) (c) The budget constraint – properties of budget set – change of budget line – taxes, subsidies and rationing (d) Optimal choice – consumer demand – price changes and income changes – normal versus inferior goods – Engel curves – income effect and substitution effect and Giffen good (e) Price Consumption Curve and the demand curve – Slutsky decomposition – ordinary versus compensated demand curve (f) Elasticity of demand – direct effect, cross effect, substitutes and compliments (g) Consumer surplus – compensating variation and equivalent variation(3L)						

	Unit 3: *Theory of Production, Cost and Firms* (a) Technology of production – production function (b) Properties of production function with one variable input – average product and marginal product (c) Law of Diminishing Marginal Returns (d) Iso-quants, input flexibility, diminishing rate of factor substitution (e) Iso-cost curves (f) Optimizing behaviour of the firm (g) Long-run and the short-run – returns to scale (h) Cobb-Douglas Production, CES Production Function (i) Measuring cost: Economic cost versus accounting cost, opportunity cost, sunk cost, fixed cost, variable cost (j) Long-run versus short-run costs (k) Economies of scale – short run and long run(3L) Unit 4: *Analyses of Market Structures: Perfect Competition* (a) Perfect Competition – assumptions – price taking behaviour (Demand curve of an individual firm) (b) Supply schedule – very short period, short period and long period (c) Equilibrium of an individual firm (d) Long run industry supply curves – constant, increasing and decreasing cost industry (e) Efficiency of competitive market – consumer and producer surplus effects of tax and subsidy, price control(3L) Unit 5: *Monopoly Market* (a) Average Revenue and Marginal Revenue (b) Monopolist's output decision (c) The effect of tax on monopoly output and price (d) Multiplant Monopolist (e) Price discrimination – First and Second Degree - Two part tariff - Third Degree (f) Monopoly Power – Mark-up Pricing (g) Social cost of monopoly (h) Dead-weight loss (i) Natural Monopoly(2L) Unit 6: *General Equilibrium and Welfare Economics* (a) Interdependence in the economy (b) 2 persons 2 goods Pure Exchange Model – Edgeworth Box Diagram (c) Contract Curve (d) Existence of Equilibrium – offer curve (e) Walras' Law (f) General Equilibrium with production – 2 good 2 factor case (g) Contract curve (h) Production Possibility Frontier (i) Pareto optimality (j) Externalities in consumption and production – market failure Group B: Macroeconomics Unit 1: *Introduction to Macroeconomic Theory (2L)* (a) Introduction to study of Economics and Macroeconomics for Engineers (b) Economy as a circular flow between firm sector and household sector – Firm, Household and Government (c) Basic Macroeconomic Variables - Configurations of Aggregate Output, Employment, Interest and Price Level (d) Fundamental Macroeconomic Problems – unemployment, inflation

	(e) Fluctuation of output – rate of growth – high unemployment, hyper -inflation, depression and stagflation Unit 2: *National Income Accounting (3L)* (a) Gross National Product (GNP) (b) Gross Domestic Product (GDP) (c) Net National Product (NNP) (d) Personal Income (PI) (e) Relation between GNP, GDP, NNP and PI (f) Nominal and Real GNP (g) GNP Deflator (h) Methods of Measurement of GNP – Measuring Gross Value of GNP – Factor Share Method, Expenditure Method, Value Addition Method (i) Foreign or External Sector Unit 3: *Determination of Equilibrium Level of Income(3L)* (a) Aggregate Demand – Components – Consumption, Investment, Government Expenditure and Net Exports (b) Consumption Function – Consumption and Savings (c) Investment Function (c) Aggregate Demand (d) Equilibrium Output – Keynesian Cross Diagram (e) Multiplier (f) Stability of Equilibrium Output (g) Paradox of Thrift (h) Government Sector – Government Budget – the Balanced Budget Multiplier (i) Taxes as a function of income (j) Multiplier and changes in tax rate (k) The Goods Market – Consumption Demand – Investment Demand (l) Planned Investment and Interest Rate (m) Goods' Market Equilibrium – IS Curve Derivation Unit 4: *Money, Interest and Income(4L)* (g) Money: Definition and Components of Money Demand and Money Supply. (h) Money Market Equilibrium – LM Curve (i) Equilibrium in goods and money market (j) Dynamic Equilibrium Condition: Changes in Equilibrium levels of income and interest rate (l) Monetary Policy – Transmission Mechanism (m)Liquidity Trap – Interest inelasticity (n) Fiscal Policy and Crowding Out (o) Effectiveness of Fiscal and Monetary Policy in terms of IS-LM Model (p) Derivation of Aggregate Demand Function (C-M Curve) Unit 5: *Inflation and Unemployment (2L)* (a) Inflation – Measures, types and effects (b) Classical Theory of Inflation – Quantity Theory of Money and Inflation (c) Keynesian Theory of Inflation (d) Concept of Inflationary Gap (e) Unemployment and Inflation – Stagflation (f) Demand pull and Cost push inflation – interaction between demand pull and cost push inflation (g) Measures of controlling inflation (h) Unemployment – Natural Rate of Unemployment (i) Philips Curve and NAIRU

	(j) Short and Long Run Philips Curve Unit 6: *Output, Price and Employment(2L)* (a) Supply of Output – Aggregate Production Function (b) Aggregate Demand for and Supply of Labour (c) Aggregate Supply Function – Relation between Aggregate Supply and Price (e) Shifts in Aggregate Demand and Supply Curve (g) Determination of Aggregate Output, Employment, Rate of Interest and Pr ice (h) Comparison of Keynesian and Classical Position – Aggregate Supply and Demand in Classical Theory (i) Neutrality of Money – Classical Dichotomy – Effects of Monetary and Fiscal Policy in Classical Framework Part 2: Management Accountancy Unit 1: INTRODUCTION TO ACCOUNTING (2L) Definition of Accountancy; Accounting vs. Book Keeping, Attributes of Accounting, Objectives of Accounting; Branches of Accounting, Users of Accounting Statements, Generally Accepted Accounting Principles (GAAP) Unit 2: Preparation of Trial Balance and Final accounts(8L) PRIMARY BOOKSOF ACCOUNTS (JOURNAL) Meaning of Journal, Format of Journals, Rules of Debit and Credit, Opening Entry, Simple and Compound entries, Numerical Problems SECONDARY BOOSOF ACCOUNTS (LEDGER) Meaning of Ledger, Formats of Ledgers, Ledger Posting, Numerical Problems Cash Book Nature of Cash Book, Different Types of Cash Books - Single Column, Double Column and Triple Column, Petty Cash Book Concept, Preparation of Trial Balance, Numerical Problems, Advantages and Limitations of Trial Balance Concepts, Procedure for the Preparation of Trading A/c, Profit and Loss A/c and Balance Sheet and different types of adjustments. Unit 3: Cost volume and profit analysis (4L)
Text Books, and/or reference material	**Text Books**: 1. Pindyck, R.S. &Rubenfeld, D. L.: Microeconomics, Pearson Education, Chapters 1, 2. 2.Varian, H. R.: Intermediate Microeconomics, EWP, Chapter 1. 3. N. G. Mankiw: Macroeconomics, Worth Publishers, Chapters 4, 6, 10 4. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed), AITBS 5.Gupta, RL and Radhaswamy, M : Financial Accounting ; Sultan Chand and Sons 6.Ashoke Banerjee: Financial Accounting, Excel Books 7.Maheshwari:Introduction to Accounting,Vikas Publishing 8.Shukla, MC, Grewal TS, and Gupta, SC : Advanced Accounts; S. Chand & Co

COURSE ARTICULATION MATRIX

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	2	1	1	2	1	1	1	-	-	2	2	2	1
CO#2	3	2	2	1	1	2	1	1	1	-	-	1	2	1	1
CO#3	1	2	1	1	1	3	2	1	1	-	1	1	3	1	2
CO#4	2	3	2	2	1	1	1	1	1	-	1	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 45				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC601	Antenna and Wave Propagation	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Electromagnetic Theory and Transmission Lines (ECC403), Microwave Engineering (ECC 502)	CT+MT+EA

Course Outcomes	• CO1 Explain the concepts of antenna radiation patterns and various parameters for characterizing the antenna. • CO2 Understand different modes of radio wave propagation. • CO3 Classify various antennas on the basis of their electrical performances. • CO4 Analyze various antennas and antenna arrays. • CO5 Design antenna and antenna arrays for different applications.
Topics Covered	**Module I: (L – 2)** **Antenna Basics:** Definition and functions of an antenna, comparison between an antenna & transmission line, radio communication link with transmitting antenna and a receiving antenna, radiation mechanism, antenna types and their applications. [CO# 1] [T1,T2] **Module II: (L – 8)** **Radiation from Electric Current Elements:** Potential functions and the electromagnetic fields, Radiation from oscillating electric dipole, quarter wave monopole; Half wave dipole; derivations of E and H field components, far field pattern, radiation resistance, Power Radiated by a current element and its application to antennas, separation of field region, application of reciprocity theorem to antennas, directional properties of dipole antennas, antenna feeding methods. Folded dipole.[CO# 1, 4, 5] [T1,T3] **Module III: (L – 7)** **Antenna Parameters:** Radiation patterns, beam area, beam efficiency, beam width- Half-Power Beam width (HPBW) and First Null Beam width (FNBW), Polarisation, Radiation Intensity, Directivity and directive gain, radiation resistance, radiation efficiency, resolution, Antenna aperture - physical and effective apertures, effective height, transmission formula, Matching – Baluns, Polarization, Polarization mismatch, Antenna noise temperature, Transmission loss as a function of frequency, Antenna temperature and signal to noise ratio. [CO# 2, 4] [T1,T2] **Module IV: (L – 6)** **Reflector, Slot and Horn antennas:** Parabolic reflector, paraboloidal reflector, Geometry, Pattern Characteristics, aperture Pattern of large circular apertures with uniform illumination, off axis operation of paraboloidal reflectors, Feed Methods, Cassegrain feed system. Slot antenna, its pattern, Babinet's principle and complementary antennas, impedance of slot antennas, and horn antenna-function and types; Rectangular Horn, Septum Horn, Ridge Horn, Corrugated Horn, Aperture Matched Horn. [CO# 3, 4, 5] [T1, T2] **Module VI: (L – 4)** **Microstrip Patch Antennas:** Advantages and Limitations, Rectangular and circular types- function, features analysis, design considerations, Feeding methods, Method of

	analysis.[CO# 3, 4, 5] [T1] **Module VII: (L – 4)** **Antenna Arrays:** Point Sources – Definition, Patterns, arrays of two antennas – Different Cases, Principle of Pattern Multiplication, Derivation of array factor expression of Uniform Linear Array with N elements – Broadside Arrays (BSA), End fire Arrays (EFA), End fire array with Increased Directivity (EFAID), Phased Scanning Arrays, Direction of nulls and maxima, Beam-width, Comparison of BSA, EFA and EFAID characteristics. Arrays with Parasitic Elements, Yagi-Uda Array[CO# 4, 5] [T1, T2] **Module VIII: (L – 7)** **Loop, Helical and Broadband Antennas:** Introduction, Small Loop, Comparison of Far Fields of Small Loop and Short Dipole, Radiation Resistances and Directivities of Small Loops (Qualitative Analysis) Helical antenna: Helical Geometry, Helix Modes, Practical Design Considerations of Helical Antenna in Axial and Normal Modes, Broadband antenna, Frequency independent antenna, log periodic antennas. Antenna Measurements-Test Ranges, Measurement of Gain, Radiation pattern, Polarization, VSWR[CO# 4, 5] [T1, T2] **Module XII: (L – 7)** **Radio Wave Propagation:** Different Modes of Wave Propagation, Structure of atmosphere, Ground Wave Propagation (Qualitative Treatment) – Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections. Space Wave Propagation – Introduction, Field Strength Variation with Distance and Height, Effect of Earth's Curvature, Absorption, Super Refraction, M-Curves and Duct Propagation, Scattering Phenomena, Tropospheric Propagation. Wave Propagation – Sky Wave Propagation – Introduction, Structure of Ionosphere, Refraction and Reflection of Sky Waves by Ionosphere, Ray Path, Critical Frequency, MUF, Virtual Height and Skip Distance, Relation between MUF and Skip Distance, Multi-hop Propagation[CO# 1, 2] [T3]
Text Books, and/or reference material	**Text Books**: [T1]. Balanis, Antenna Theory and Design, Wiley Publications [T2]. John D. Krauss, Antennas for all Applications, TMH. [T3]. Edward C.Jordan and Keith G.Balmain" Electromagnetic Waves and Radiating Systems" Prentice Hall of India. **Suggested Reference Books**: [R1]. R.E.Collin,"Antennas and Radiowave Propagation", McGraw Hill 1985. [R2]. Constantine.A.Balanis "Antenna Theory Analysis and Design", Wiley Student Edition, 2006. [R3]. Rajeswari Chatterjee, "Antenna Theory and Practice" Revised Second Edition New AgeInternational Publishers, 2006. [R4]. S. Drabowitch, "Modern Antennas" Second Edition, Springer Publications, 2007. [R5]. Robert S.Elliott "Antenna Theory and Design" Wiley Student Edition, 2006. [R6]. H.Sizun "Radio Wave Propagation for Telecommunication Applications", First Indian Reprint,Springer Publications, 2007.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	2	1	1	2	1	1	1	-	-	2	2	2	1
CO#2	3	2	2	1	1	2	1	1	1	-	-	1	2	1	1
CO#3	3	3	1	1	1	-	-	-	-	-	-	1	3	1	1
CO#4	1	2	1	1	1	3	2	1	1	-	1	1	3	1	2

CO#5	2	3	2	2	1	1	1	1	1	-	1	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low)   2: Moderate (Medium) 3: Substantial (High)

Department of Electronics & Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC602	VLSI Design	PCR	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))				
Digital Circuits and Systems (ECC402)			Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance				

Course Outcomes

After successful completion of the course, the student will be able to:

- **CO 1:** Acquire idea about the digital IC design techniques.
- **CO 2:** Understand the characteristics of the CMOS inverter.
- **CO 3:** Identify the basic steps of ASIC Design Flow and fabrication process.
- **CO 4:** Analyze the static and dynamic characteristics of CMOS circuits.
- **CO 5:** Design and implementation of combinational and sequential circuits.
- **CO 6:** Evaluate the performance of CMOS circuits.

Topics Covered

Module I. Overview of VLSI Design [L – 6]
Historical perspective, an overview of VLSI design methodologies, VLSI design flow, design hierarchy, concepts of regularity, modularity, and locality, VLSI design styles, design quality, packaging technology, CAD technology, Recent Trends in VLSI Design & its research issues in the industry: System case studies. Design automation of VLSI Systems: basic concepts. Deep Sub-micron Technologies: Some Design Issues.

Module II. MOS Transistor Theory [L – 4]
Introduction to The metal oxide semiconductor (MOS) structure, Long-channel I-V characteristics, C-V characteristics, non-linear I-V effects, DC transfer characteristics, sub-threshold swing in MOSFET, multi-Vt.

Module III. ASIC Design Flow [L – 6]
ASIC and SoC, Overview of ASIC flow, concepts of HDL coding, functional verification, RTL-GATE level synthesis, synthesis optimization techniques, pre-layout timing verification, static timing analysis, floor-planning, placement and routing, extraction, post-layout timing verification, extraction.

Module IV. CMOS Process Technology[L – 2]
Fabrication process flow- basic steps, the CMOS n-Well process, layout design rules, stick diagram, full-custom mask layout design.

Module V. MOS Inverter- Static Characteristics [L – 4]
Resistive-load inverter, inverter with n-type MOSFET load, CMOS inverter.

Module VI. MOS Inverters- Switching Characteristics & Interconnects effects [L-6]
Delay-time definitions, calculation of delay times, logical efforts, inverter design with delay constraints, estimation of interconnect parasitics, calculation of interconnect delay, Bus vs. Network-on-Chip (NoC), switching power dissipation of CMOS inverters.

Module VII. Combinational CMOS Logic Circuits[L – 7]
MOS logic circuits with depletion nMOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (pass gates), ratioed, dynamic and pass transistor logic circuits, domino circuits.

Module VIII. Sequential CMOS logic circuits [L – 7]

	Behavior of bi-stable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch, and edge-triggered flip-flop. Timing path, Setup time and hold time static, the example of setup and hold time static, setup and hold slack, clock skew and jitter, Clock, reset, and power distributions.
Text Books, and/or Reference Material	**Text Books:** 1. N. H. E. Weste and C. Harris, "*Principles of CMOS VLSI Design: A System Perspective*", 3rd Edition, Pearson Education 2007. 2. Sung-Mo Kang, Yusuf Leblebici, Chulwoo Kim, "*CMOS Digital Integrated Circuits*", 4th edition, McGraw-Hill, 2018. **Reference Book:** 1. Jan M. Rabaey, AnanthaChandrakasan, BorivojeNikolic, "*Digital Integrated Circuits: A Design Perspective*", 2nd Edition, Pearson Education, 2009.

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	2	1	2	2	1	1	1	1	1	2	3	2
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 56				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC603	Digital Signal Processing	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT),End Assessment (EA))					
Signals and Systems (ECC303), Mathematics-II & III (MAC02, MAC331)		Class Assignments, Mid and End term examinations					
Course Outcomes	On successful completion of this course, students should have the skills and knowledge to: **CO1**. Represent signals in time and frequency domain. **CO2**. Implement DFT, FFT and z-transform. **CO3**. Analyse a given signal or system using tools such as Fourier transform and z-transform to know the property of a signal or system. **CO4**. Design of prototype of Linear Phase Filters, FIR and IIR Filter Structure. **CO5**. Process signals to make them more useful and to design a signal processor (Digital filter structures) for a given problem.						
Topics Covered/ Syllabus	Introduction: reasons behind digital processing of signals, brief historical development, organization of the course. (L=2) Theory of discrete time linear system sequences, linear time invariant systems, causality, stability, difference equations, frequency response, discrete Fourier series, relation between continuous and discrete systems, Inverse Systems, Stability. (L=2, T=1)						

	Z –transform: definition, properties of Z transform, system function, digital filter implementation from the system function, region of convergence in the Z plane, determining filter coefficients from the singularity locations, geometric evolution of Z transform in the Z plane, relationship between Fourier transform and Z transform, inverse Z transform. (L=4, T=1) Transform technique: Fourier transform, its properties, inverse Fourier transform, discrete Fourier transform, properties of DFT, circular convolution, computations for evaluating the DFT, decimation in time and decimation in frequency FFT algorithms, discrete Hilbert transform. (L=5, T=2) Digital filter structures: system describing equations, filter categories, All Pass Filters, Comb Filters, direct form I and II structures, cascade and parallel communication of second order systems, Polyphase representation of filters, linear phase FIR filter structures, Compensatory Transfer Functions, frequency sampling structure for the FIR filter. Test for Stability using All Pass Functions. (L=6, T=2) IIR filter design techniques: Analog Filter Design, Analog Butterworth lowpass filter design techniques, Analog Chebyshev LPF, Design methods to convert analog filters into digital filters, frequency transformation for converting lowpass filters into other types, all-pass filters for phase response compensation. (L=6, T=2) Digital Filter Structures: IIR Realizations, All Pass Realizations, FIR and IIR Lattice Synthesis, IIR Design by Bilinear Transformation, Digital to Digital Frequency Transformation. (L=6, T=2) FIR filter design techniques: Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filter, frequency sampling method for designing FIR filter (L=6, T=2) Non-Linear System Identification Schemes, Fractional-order digital differentiators (DDs) and digital integrators (DIs), Fractional-order low-pass Butterworth and Chebyshev filter. (L=5, T=2)
Text Books, and/or Reference material	**Text Books**: 1) Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India 2) Digital Signal Processing: Principles, Algorithms and Applications (3rd Edition), John G. Proakis, Dimitris G. Manolakis, and D Sharma, Pearson Education India 3) Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 1996. ISBN:0201634678. 4) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937
	Reference Books/materials: 1) S. W. Smith, The Scientist and Engineer's and Guide to Digital Signal Processing, California Technical Publishing, 1997. ISBN: 0-9660176-3. 2) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	1	-	-	-	-	-	-	2	3	1	1
CO#2	3	3	2	2	2	-	-	-	-	-	-	3	3	1	1
CO#3	3	3	2	3	2	-	-	-	-	-	-	3	3	3	1
CO#4	3	3	3	3	2	-	-	1	-	-	-	3	3	3	2
CO#5	3	2	3	3	2	1	-	-	-	-	-	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 27				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS651	Antenna and Wave Propagation Laboratory	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), and end assessment (EA))
Electromagnetic Theory and Transmission Lines (ECC403) and Microwave Engineering (ECC 502), Microwave Engineering Lab (ECS552)	Day to day evaluation during the laboratory session and End Semester Examination

Course Outcomes	After successful completion of this course, the students will be able to CO#1: Understand theory of EM wave propagation and power transmission through free space medium. CO#2: Compare the radiation characteristics of different antenna and antenna arrays CO#3: Analyze the radiation characteristics of different antennas in terms of their radiation parameters. CO#4: Use of VNA to study antenna characteristics. CO#5: Identify the suitable antenna for the application different communication systems. CO#6: Design a particular antenna as per the requirements of given specifications.
List of Experiments	7. To plot the radiation pattern of half wave dipole antennas. 8. To plot the radiation pattern of half wave monopole antenna. 9. To plot the radiation pattern of half wave folded dipole antenna. 10. To study the radiation characteristics of Yagi-Uda antenna. 11. To the radiation characteristics of log periodic dipole antenna 12. To plot the radiation pattern of microstrip patch and slot antennas 13. Measurement of return loss of a given antenna using Network Analyzer 14. Study of radiation pattern of Horn antenna and understand the Friis transmission equation 15. To observe the characteristics of microstrip antenna using EM simulation software.
Text Books, and/or reference material	**Reference Materials:** [T4]. Laboratory Instruction Manual and Operation Manual of the Manufacturer [T5]. http://www.electronics-tutorial.net/lab-test-and-measurement/Antenna-and-Wave-Propagation/Exp-9/ [T6]. Balanis, Antenna Theory and Design, Wiley Publications

COURSE ARTICULATION MATRIX

Mapping CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome):

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	2	1	1	-	-	-	-	1	1	-	1	3	2	2
CO#2	3	2	1	1	-	-	-	-	1	1	-	1	2	1	1

CO#3	3	2	1	1	-	-	-	1	1	1	-	1	3	3	2
CO#4	3	2	2	1	1	-	-	-	1	1	1	1	3	3	2
CO#5	3	2	2	2	1	-	-	-	1	1	-	1	3	1	1
CO#6	3	3	3	1	-	-	-	-	1	1	-	1	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 30</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS652</td><td>VLSI Design Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic Electronics (ECC01), Physics of Semiconductor Devices (PHC331), and Digital Circuits and Systems (ECC402)</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understanding of HDL coding and simulation using EDA tools
• CO2: Analyze the combinational circuits
• CO3: Analyze the sequential circuits
• CO4: Design and implementation of combinational circuits
• CO5: Design and implementation of sequential circuits</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of experiments
1. Design and Implementation of combinational circuits using data flow or gate-levelmodeling along with their test bench
I. Basic Gates (CO#2, CO#4)
II. Half-Adder and Full-Adder (CO#2, CO#4)
III. Half-Subtractor and Full-Subtractor (CO#2, CO#4)
IV. 2:4 Decoder (CO#2, CO#4)
V. 8:3 Encoder (CO#2, CO#4)
VI. Parity Checker (CO#2, CO#4)
VII. 8:1 Multiplexer (CO#2, CO#4)
VIII. 1:4 De-multiplexer (CO#2, CO#4)
IX. Binary to gray converter (CO#2, CO#4)
X. Gray to binary converter (CO#2, CO#4)
XI. 2-bit magnitude comparator (CO#2, CO#4)
2. Design and Implementation of sequential circuits along with their test bench
I. Design and simulation of Flip-flops (RS FF, JK FF, T FF, D FF& Master-slave FF) using VHDL\ Verilog (CO#1, CO#3, CO#5)
II. Design and simulation of Counters (Synchronous and Asynchronous) using VHDL\ Verilog. (CO#1, CO#3, CO#5)
III. Design and Simulation of Shift registers (SISO, SIPO, PISO & PIPO) using VHDL\ Verilog. (CO#1, CO#3, CO#5)
IV. Design an Arithmetic unit using VHDL\ Verilog. (CO#1, CO#3, CO#5)
3. Spec. to GDSII using QFlow chains
<u>Specifications:</u> Two counters – one clocked by an external clock, the other by</td></tr>
</table>

	an internally generated clock. All clocks have to be identified for static timing to work correctly. Total 40 flip-flips are nowhere near the limit in terms of area for this chip size. Only four outputs and two inputs, power, and ground. The total is 8 pins. (CO#1, CO#3, CO#5)
Text Books, and/or reference material	**Text Book**: 1.Samir Palnitkar, "Verilog HDL," Second Edition, Pearson education 2003

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	2	2	2	1	1	1	1	1	1	1	1	2	3	2
CO#2	2	2	2	2	3	1	1	1	1	1	1	1	2	3	2
CO#3	2	2	2	2	3	1	1	1	1	1	1	1	2	3	2
CO#4	2	2	2	2	3	1	1	1	1	1	1	1	2	3	2
CO#5	2	2	2	2	3	1	1	1	1	1	1	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 30				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS653	Digital Signal Processing Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MATLAB, Signals & Systems (ECC 303)		Quizzes and Lab Assessments					
Course Outcomes	On completion of the experiments conducted, students will be able to: CO#1: Generate different types of digital signals CO#2: Sampling, reconstruction, linear and circular convolution between signals CO#3: Simulate impulse response of systems from difference equations CO#4: Study the frequency response of LTI systems CO#5: Carry out Discrete Fourier Transform and Fast Fourier Transform CO#6: Design different Digital Filters						
Topics Covered/ Syllabus	***A. Introduction to digital signals and systems:*** **Experiment 1:** Generate and plot the following sequences: i. Unit sample sequence ii. Unit step sequence iii. Unit ramp sequence iv. Real valued exponential sequence $x(n)=(0.8)^n u(n);0\le n\le 50$ v. Square wave and Sawtooth wave sequence of length 50, having peak						

amplitude 5.

Experiment 2:

a) Generate a 50 Hz continuous time sinusoidal signal $x(t) = A\cos(2\pi ft)$ having frequency of 50 Hz and its sampled version with sampling frequency 1000 Hz. Assume the amplitude as 5.

b) Write a program to generate a signal $x(n) = u(n) - u(n-10)$. Also plot the even and odd component of the signal.

B. Sampling, reconstruction and convolution of signals:

Experiment 3:

Consider an analog signal $x(t) = \sin(20\pi t); 0 \le t \le 1$. It is sampled at sampling time interval (T_s) as 0.01 second to obtain $x(nT_s)$. Reconstruct the analog signal from the sampled signal using *sinc* interpolation.

Experiment 4:

a) Evaluate the convolution sum for a system whose impulse response $h(n)$ and input $x(n)$ are same and are described as:

$$x(n) = h(n) = \left[u(n+N) - u(n-N-1)\right]$$

b) Find the linear convolution of the following signals:

$$\underset{\uparrow}{x(n) = \{2,1,3,5,9\}} \quad \text{and} \quad \underset{\uparrow}{h(n) = \{5,5,8,9,2\}}$$

c) Write down a program to compute the correlation of the following sequence.

$$\underset{\uparrow}{x(n) = \{1,4,1,3\}}$$

C. Difference equation and impulse response:

Experiment 5:

a) Find the impulse response of the following system: y(n) -0.6y(n-1) +0.08y(n-2) = x(n)

b) Find the step response of the system y(n)=0.7y(n-1)-0.12y(n-2)+x(n-1)+x(n-2) with the initial condition y(-1)=1,y(-2)=1.

c) An LTI system is specified by the difference equation y(n) = 0.8y(n-1) + x(n) Determine H(e^{jw}). Also calculate and plot the steady state response for the input x(n) = cos(0.05πn)u(n)

D. Frequency domain transforms:

Experiment 6:

d) A symmetrical rectangular pulse is given by

$$x(n) = 1; -N \le n \le N$$
$$0; \text{otherwise}$$

Determine the DTFT for N=2, 5, 10, 15. Scale the DTFT so that $X\left(e^{j0}\right) = 1$. Plot the normalized magnitude response of the DTFT over $\left[-\pi, \pi\right]$, Study these plot and comment on their as a function of N.

e) Determine and plot the DTFT of a sinusoidal signal

$x(n) = \cos\left(\frac{\pi n}{4}\right); 0 \le n \le 100$. Also investigate the periodicity.

<table>
<tr><td></td><td>

Experiment 7:

a) A discrete time LTI system is represented by a first order difference equation
$y(n)=ay(n-1)+x(n);n\geq 0$
where $x(n)$ is the input of the system and $y(n)$ is the corresponding output. For an input $x(n)=u(n)-u(n-1)$, zero initial condition and $a=0.8$, find and plot $y(n)$.

Given a causal system $y(n)=0.9y(n-1)+x(n)$, find $H(z)$ and plot its poles and zeros. Also plot the frequency response $\left|H\left(e^{jw}\right)\right|$ and $\angle H\left(e^{jw}\right)$.

E. Discrete Fourier Transform and Fast Fourier Transform:

Experiment 8:

a) Consider a 9-point sequence $x(n)=\{1,2,3,4,5,6,7,8,9\}$. Determine and plot the sequences $x\langle\langle n-3\rangle_9\rangle$ and $x\langle\langle n+3\rangle_9\rangle$.

b) Let $x_1(n)=\{1,2,2,1\}$ and $x_2(n)=\{1,2,3,4\}$ .Write a program to perform 4-point circular convolution of these two signals. Also find the linear convolution of these two signals using circular convolution.

Experiment 9:

Compute the output of a linear filter described by impulse response
$h(n)=\{1,2,3,1,2\}$ and input $x(n)=\{1,1,1,1\}$ using fft command.

F. Digital Filters:

Experiment 10:

a) For the desired frequency response
$H_d\left(e^{j\omega}\right)=e^{-j\omega\tau};\omega_{c1}\leq|\omega|\leq\omega_{c2}$
$0;|\omega|<\omega_{c1},\omega_{c2}<|\omega|\leq\pi$

Determine $H\left(e^{j\omega}\right)$ for M=35 using Blackman window if $\omega_{c1}=\frac{\pi}{4}$ and $\omega_{c2}=\frac{\pi}{2}$.

b) Implement type 1, 2, 3, 4 linear phase FIR filter.

Experiment 11:

a) Write a MATLAB program to design an IIR low pass Butterworth filter using the impulse invariant method for the following specifications:
$0.8\leq\left|H\left(e^{j\omega}\right)\right|\leq 1;|\omega|\leq 0.2\pi$
Assume T=1 second.
$\left|H\left(e^{j\omega}\right)\right|\leq 0.2;0.6\pi\leq|\omega|\leq\pi$

b) Write a MATLAB program to design a digital low pass Butterworth filter to satisfy the following specifications:

Pass band cutoff=0.2π, pass band attenuation= 7 dB, stop band cutoff= 0.3π, stop band attenuation= 16 dB using Bilinear Transformation method. Assume T= 1 second.

</td></tr>
<tr><td>Text Books, and/or Reference material</td><td>

Text Books:

1) Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India

2) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937

</td></tr>
</table>

	Reference Books/Materials: 1) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	2	2	2	-	-	-	-	-	1	-	2	3	1	1
CO#2	3	3	3	2	-	-	-	-	-	1	-	1	3	1	1
CO#3	3	3	2	3	2	-	-	-	-	1	-	1	3	3	1
CO#4	3	3	2	3	2	-	-	-	-	1	-	1	3	3	2
CO#5	3	3	3	1	1	-	-	-	1	1	-	2	3	2	1
CO#6															

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE610	Artificial Intelligence and Soft Computing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous (CT), mid-term (MT) and End Assessment (EA)					
Introduction to Computing (CSC01) & Computer Programming Languages like Python, C++, Matlab etc.		CT+MT+EA					
Course Outcomes	After the completion of the course the student will be able to learn the following: •CO1: Basics of optimization and soft computing algorithms •CO2: Learn different soft computing algorithms •CO3: Learn artificial neural network and its training •CO4: Study of radial basis function neural and its training •CO5: Study of machine learning algorithms and clustering						
Topics Covered	**Module I.Introduction to Optimization and soft computing algorithms** [L-8] Introduction to optimization, Constrained and unconstrained optimization, Introduction to Optimization based on soft computing, Genetic algorithms, particle swarm optimization **Module II.Review of different soft computing algorithms part-I** [L-7] Flower pollination algorithm, Teaching learning based optimization **Module III.Review of different soft computing algorithms part-II** [L-5] Crow search algorithm, Quantum Particle swarm optimization **Module IV.Basics of artificial neural network and its training** [L-7] Introduction to artificial neural network, Supervised Learning Neural Networks, Perceptrons, Adaline, Multilayer feed forward neural network, Training of neural network using backpropagation algorithm						

	Module V. Radial basis function neural networks and K-means clustering [L-5] Radial Basis Function Neural Networks (RBF), Training of RBF using pseudo inverse technique ,Data clustering using K-means **Module VI.Study of machine learning algorithms** [L-10] Extreme learning machine (ELM), Training and testing of ELM, Recurrent Neural Network(RNN) and long short-term memory (LSTM),Training a LSTM based RNN, Deep learning and Convolutional Neural Network(CNN).
Text Books, and/or Reference material	**Text Books**: 1.S N Sivanandam, S.N.Deepa, "Principles of Soft Computing," Wiley,3rd edition,2018 2.Samir Roy &Udit Chakraborty, "Introduction to Soft Computing," Pearson,1st edition,2013 3.Satish Kumar, " Neural Networks: A Classroom Approach",McGraw-Hill (India), 2013 4.Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms, "Cambridge University Press",2014
	Reference books: 1.S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI,2003 2.Jang, Sun, Mizutani, "Neuro-Fuzzy and Soft computing", Pearson,2015 3.Simon Haykin, "Neural networks and learning machines," Pearson,3rd edition,2009 4.Charu C.Aggarwal, "Neural Networks and Deep learning,"Springer,2018

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	1	1	2	1	1	1	1	1	1	2	3	2
CO#2	3	3	3	2	2	2	1	1	1	1	1	1	3	2	2
CO#3	3	3	2	2	2	1	2	1	1	1	1	1	3	3	2
CO#4	3	2	2	3	3	2	1	1	1	1	1	1	3	3	2
CO#5	3	2	2	2	2	2	1	1	1	1	1	1	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE611	Computer Organization and Architecture	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
Digital Circuits and Systems (ECC402), Microprocessors and Microcontrollers (ECC503)		The assessment methods comprise of quizzes, multiple choice type questions, and subjective questions all either designed in google form or assessed through pen and paper.					

Course Outcomes	After successful completion of the course, the student will be able to: ● **CO 1:**Acquire idea about computer architecture and organization. ● **CO 2:**Understand the fundamental concepts of ISA. ● **CO 3:**Illustrate the operations of the memory unit. ● **CO 4:**Analyzethe control and data flow of a computer. ● **CO 5:**Design and implementation of multiprocessors. ● **CO 6:** Evaluate the performance of a computer system.
Topics Covered	**Module I. Introduction and Basics [L – 4]** History of computers, introduction to computer architecture, level of transformation, abstract layers, their benefits of comfortably crossing them, instruction set architecture I, instruction set architecture II, instruction set architecture III, architecture examples, example problem, and solution ideas. **Module II. Fundamental Concepts and ISA [L – 6]** Fundamental concepts in computer architecture: Von Neumann model and data flow model, ISA principles and trade-off, elements of an ISA, RISC vs. CISC, MIPS ISA, ISA vs. microarchitecture level trade-off, property of ISA vs. microarchitecture. **Module III. Arithmetic Operations [L – 5]** Binary arithmetic, ALU Design, multiplier design, divider design, fast addition, multiplication, floating-point arithmetic. **Module IV. Processor Design [L – 8]** Single-cycle microarchitecture, multi-cycle microarchitecture, microprogrammed microarchitecture, pipelining: issues in pipelining, data and control dependence handling, branch prediction, precise exceptions, state maintenance, state recovery; Out-of-Order execution and issues in OoO execution. **Module V. SIMD, GPUs, VLEW and DAE [L – 5]** SIMD processing: array and vector processors, SIMD operation in modern ISAs, VLIW, Decoupled Access Execute (DAE), Systolic Array. **Module VI. Memory Hierarchy and Caches [L - 7]** Memory hierarchy, physical memory and virtual memory, emerging memory technologies, main memory, memory controller, memory management, memory latency tolerance: prefetching, Cache organization and operation, high-performance caches, memory consistency, and cache coherence, in-memory processing **Module VII. Multiprocessor [L – 7]** Multiprocessor types, multiprocessing, and issues in multiprocessor, limits of parallel speedup, difficulty in parallel programming, heterogeneous systems, input/output subsystem, interfaces, I/O operations, interconnection networks: bus-based and NoC based architectures.
Text Books, and/or reference material	**Text Books:** 1. Patterson and Hennessy, "Computer Organization and Design: The Hardware/Software Interface", 4th Edition, Morgan Kaufmann/ Elsevier, 2009. 2. W. Stallings, "Computer architecture and organization: Designing for Performance" Pearson Education; 9th edition (1 January 2013) **Reference Books:** 1. Andrew Tanenbaum, "Structured Computer Organization"6th Ed, Pearson, 2016. 2. Patt and Patel, "Introduction to Computing Systems: From Bits and Gates to C and Beyond", Morgan Kaufman, Elsevier, 2th Edition, McGraw-Hill Education 2003. 3. Harvey Cragon, "Computer Architecture and Implementation", Cambridge University Press, 2000. 4. C. Hamacher, Z. Vranesic, S. Zaky, "Computer Organization", McGraw Hill Education; 5th Edition, 2011.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO# 1**	**PO# 2**	**PO# 3**	**PO# 4**	**PO# 5**	**PO# 6**	**PO# 7**	**PO# 8**	**PO #9**	**PO# 10**	**PO# 11**	**PO# 12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	3	3	3	2	1	2	1	1	1	1	1	1	3	3	2
CO#2	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO#3	3	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	3	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#6	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:
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Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE612	Advanced Digital Communication	PEL	3	0	0	3	3
Pre-requisites		Continuous Assessments: Class Assessment (CA), Mid-Sem (MA) and End-Sem assessment (EA)					
Signals and Systems (ECC303), Analog Communication (ECC401), Digital Communication (ECC501), Probability Theory for Engineering Application (ECO541) / any other equivalent subject from SWAYAM, NPTEL,etc.		(CA-15) +(MA-25) + (EA-60)					

Course Outcomes

- CO1: **Identify** the fundamental differences between analog and digital communication systems and the explicit need to study digital communication as a separate course. **Identify** building blocks that constitute a digital communication system.
- CO2: **Explain** why each building block is necessary and the working principle of each such block.
- CO3: **Apply** geometric concepts to understand signal constellations and its variants. **Apply** signal processing tools to infer time and frequency domain representation of signals in context to digital communications.
- CO4: **Analyze** error performance of digital communication systems in the presence of additive noise.
- CO5: **Evaluate and access** communication systems based on resource availability (bandwidth, power, etc.) and performance requirement (BER, SER, etc.).
- CO6: **Develop** strong mathematical foundation and intuition to **pursue any advanced topic in communications** (wireless communication, detection and estimation theory, etc.).

Topics Covered	1. **Introduction** **(1 hr.)** 2. **Module-1** **(3 hrs.)** Review of Autocorrelation, Cross correlation**,** Energy Spectral Density (ESD) and Power Spectral Density (PSD) **3. Module-2 :(3 hrs.)** Complex baseband representation of real bandpass signals, real bandpass LTI systems **4. Module-3 :(3 hrs.)** Digital communication through band-limited channels **5. Module-4 : (3 hrs.)** Signal Space and Signal Vector : Geometrical representation of signals **6. Module-5 : (7 hrs.)** Optimum receivers for AWGN channels: Maximum likelihood decoding of M-ary signals – Correlation receiver and Matched filter receiver, SER and BER **7. Module-6 :(5 hrs.)** Basics of Detection and Estimation theory **8. Module-7 : (5 hrs.)** Advanced modulation technique : Coherent and noncoherent modulation, MSK, M-arymodulation techniques (QPSK, QAM etc.) **9. Module-8 : (6 hrs.)** Spread spectrum for digital communications : Pseudo-Noise Sequence, Direct-Sequence Spread Spectrum, Frequency-Hop Spread Spectrum, Slow FHSS, Fast FHSS, Applications of Spread Spectrum **10. Module-9 :(6 hrs.)** Multichannel communications and OFDM : Principle of OFDM, Multicarrier modulation technique, FFT/IFFT and OFDM, OFDM transmitter, OFDM receiver, BER performance of OFDMsystem
Text Books, and/or reference material	**Text Books**: 1. S. Haykin, “Digital Communication Systems” , Feb 2013, John Willey 2. J. G. Proakis and M. Salehi “Digital Communications”, 2014 (6th edition), McGrawhill 3. Bernard Sklar, “Digital Communications” (2nd edition), Pearson Education **Reference Books**: 1. NOC : “Modern Digital Communication Techniques”, Prof. SuvraSekhar Das, IIT Kharagpur, URL : https://nptel.ac.in/courses/117/105/117105144/ 2. Richard van Nee &Ramjee Prasad “OFDM for Multimedia Communications”, Artech House

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	2	2	2	2	1	1	1	1	1	1	1	3	2	1
CO#2	2	2	2	2	2	1	1	1	1	1	1	1	3	2	1
CO#3	3	3	3	3	2	1	1	2	1	1	1	1	3	3	1
CO#4	3	3	3	3	2	1	1	2	1	1	1	1	3	3	1
CO#5	3	3	3	3	2	1	1	2	1	1	1	1	3	3	1
CO#6	2	2	2	1	1	1	1	1	1	1	1	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE613</td><td>Object Oriented Programming</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT),End Assessment (EA))</td></tr>
<tr><td colspan="2">Introduction to Computing (CSC01)</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: Implement programs using classes and objects
CO2: Specify the forms of inheritance and use them in programs
CO3: Analyze polymorphic behavior of objects
CO4: Introduce Templates and Exception Handling
CO5: Design and write programs using an object oriented language
CO6: Apply object oriented approach to design software</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Overview-[3L]
Programming in general; Programming paradigms-Procedural, Functional, Logic and Object Oriented; Basics of Object Oriented Programming; Available Object Oriented Languages; Program Compilation; Object Oriented Programming Terms – Class, Object, Encapsulation, Abstraction, Polymorphism, Inheritance, Static and Dynamic Binding.
Revisiting Array, Pointer and Structure – [2L]
Defining arrays and accessing array elements; Array initialization and assigning values to array elements; Multidimensional arrays; Addresses and Pointers; Void pointer, address-of and indirection operator; Pointer to pointers; Difference of Pointer and Array; Pointer arithmetic; Defining structures
Revisiting Functions- [2L]
Declaration, definition and call of a function; Inline functions; Main function arguments; Reference variables; Function overloading; Parameter passing concepts- call by value vs. call by reference; Concept of recursion; Scopes of variables; Return from functions by value as well as by reference; Pointer to functions.
Data Abstraction through Classes and User Defined Data Types- [4L]
C-struct and defining user defined data types through typedef; Class, Object, and members of a class; Constructor and Destructor; Dynamic memory management using new and delete operator (C++) ormalloc and free (C-way); this operator; Static members of a class; Additional scope of variables.
Operator Overloading-[4L]
Operator overloading techniques and restrictions; Overloading unary and binary operators; Overloading function operator, index operator, class member access, and cast operator; User defined conversions through constructors or cast operators; Overloaded non-member operators outside the class; Overloading new and delete operators.
Class Relationships– [4L]
The concept of inheritance- single and multiple; Constructor and Destructor calling sequences; Virtual base class; Accessibility in friends and derived classes; Virtual function and operator; Linking C file in C++ program.
Advanced Concepts – [4L]
Concept of template- class and function templates; Namespace; Need and mechanism of exception handling; Advanced cast operators- static_cast, dynamic_cast, reinterpret_cast, and</td></tr>
</table>

	const_cast; *typeid* operator **Standard Library in C++- [4L]** Standard C++ library functions for input and output handling; Standard Template Library **Data Structures and Applications in C++ - [4L]** Several fundamentally used data structures as array and linked list where from other data structures like stack, queue, tree, can be made **Object Oriented Design and Modelling–[4L]** Software development process from software engineering and quality perspective; Software architecture concepts; Best practices of software development; Phases of software development- inception, elaboration, construction, and transition; Object Oriented principles and concepts; Object Oriented modelling from views of Booch, Rumbaugh, Jacobson **Unified Modelling Language – [4L]** Basic building blocks of UML; Use case and actors; Structural and behavioural modelling aspects; Packaging and deployment; Software development process through UML. **Laboratory Workouts – [3L]**
Text Books, and/or reference material	**Text Books**: 1. BjarneStroustrup "The C++ Programming Language", Pearson Education 2. Debasish Jana, "C++ and Object Oriented Programming Paradigm", Prentice Hall of India Pvt. Ltd. **Reference Books**: 1. Bruce Eckel, "Thinking in C++", Prentice Hall 2. S. B. Lippman, J. Lajoie, B. E. Moo, "C++ Primer", Addison-Wesley Professional 3. BjarneStroustrup, "Programming: Principles and Practice Using C++", Addison-Wesley Professional 4. Effective C++: 50 Specific Ways to Improve Your Programs and Design by Scott Meyers, 1997

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) and PO (Programme Outcome)& PSO

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2	1	1	1	1	1	2	1	3	1	1	1
CO2	2	3	2	3	1	1	1	1	1	2	1	3	2	1	1
CO3	2	3	2	3	1	1	2	1	1	1	1	3	2	1	1
CO4	3	2	2	2	1	1	2	1	1	1	1	3	2	1	1
CO5	3	3	3	3	1	1	2	1	2	3	1	3	1	1	1
CO6	3	2	3	3	3	1	2	1	2	3	2	3	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics & Communication Engineering							
Course Code	Title of the course	Program Core (PCR)/ Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE614	ASIC Design using Verilog/VHDL	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))				
Digital Circuits and Systems (ECC402)			Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance				
Course Outcomes	After successful completion of the course, the student will be able to: • **CO 1:** Explain VLSI design flow using HDL. • **CO 2:** Analyze and design combinational and sequential digital systems. • **CO 3:** Employ EDA tools to model a digital system. • **CO 4:** Write test benches to verify the design. • **CO 5:** Compare between blocking and non-blocking statement and their uses. • **CO 6:** Create a System from simulation to synthesizable design.						
Topics Covered	**Module I. Brief introduction to VLSI using CAD tools [L - 3]** Overview of Digital Design with Verilog HDL: Evolution of CAD, the emergence of HDLs, typical HDL-based design flow, Verilog HDL, Trends in HDLs. **Module-II.Hierarchical Modeling Concepts [L – 3]** Top-down and bottom-up design methodology, differences between modules and module instances, parts of a simulation, design block, stimulus block. **Module-III. Basic Concepts [L – 3]** Lexical conventions, data types, system tasks, compiler directives.Memory modeling Logic Synthesis: Introduction synthesis of different Verilog constructs. **Module-IV. Modules and Ports [L – 3]** Module definition, port declaration, connecting ports, hierarchical name referencing. **Module-V. Gate-Level Modeling [L – 2]** Modeling using basic Verilog gate primitives, description of and/or and buf/not type gates, rise, fall and turn-off delays, min, max, and typical delays. **Module-VI. Dataflow Modeling [L – 3]** Continuous assignments, delay specification, expressions, operators, operands, operator types. **Module-VII. Behavioural Modeling [L – 3]** Structured procedures, initial and always, blocking and nonblocking statements, delay control, generate a statement, event control, conditional statements, multiway branching, loops, sequential and parallel blocks **Module-VIII. Tasks and Functions [L – 4]** Differences between tasks and functions, declaration, invocation, automatic tasks, and functions. **Module-IX. Useful Modeling Techniques [L – 4]** Procedural continuous assignments, overriding parameters, conditional compilation and execution, useful system tasks. **Module-X. Flip-Flop and Counter Design [L – 4]** Synchronous and asynchronous flip flop design with set and reset, design of basic counters. **Module-XI. FSM & Processor Design [L – 6]** FSM modeling, Data path and Controller design, Modeling Memory, Pipelining, and Design of a Processor. Introduction to Reconfigurable computing, FPGAs, the Altera /Xilinx flow. **Module-XII. Essential System Verilog for UVM [L – 4]**						

	Overview of basic SystemVerilog, UVM verification environment: introduction to UVM methodology and universal Verification Components (UVC) structure, stimulus modeling, creating a simple environment, DUT, TLM, functional coverage modeling, register modeling in UVM.
Text Books, and/or Reference Material	**Text Books:** 1. Samir Palnitkar, "*Verilog HDL,A Guide to Digital Design and Synthesis*", Second Edition, Pearson Education, 2004 2. J. Bhaskar, "*Verilog HDL Synthesis*", BS publications, 2001. **Reference Books/Materials:** 1. S. Brown and Z. Vranesic, Fundamentals of Digital Logic with Verilog Design, McGraw Hill, Third Edition 2013. 2. G. De Micheli. Synthesis and optimization of digital circuits, McGraw Hill, 2003 3. IndranilSengupta, IIT Kharagpur, "*NPTEL Course on Hardware Modeling using Verilog*" (2017) https://www.youtube.com/watch?v=NCrlyaXMAn8&list=PLRsFfXmDi9IYCNlvNjrsD8bLMmNE0UxBH

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	1	3	2	1	1	1	1	1	1	1	1	1	2	3	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE615	Active Filter Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT),End Assessment (EA))					
Electronic Devices and Circuits I (ECC302), Signal and Systems (ECC303)		Class Assignments, Mid and End term examinations					
Course Outcomes		After the completion of the course, the student will be able to: • CO1: Explain the operation of various High performance filters. • CO2: Design Analog Circuits. • CO3: Create the Layout of filters. • CO4: Analyze the performance of different active filters. • CO5: Interpret the use of Analog filter • CO6: Compare the architectures based on Area/Power/Speed.					

Topics Covered/ Syllabus	**Module-I:**[L-5] Introduction, Butterworth approximation, Chebyshev approximation, Inverse Chebyshev approximation, Synthesis of doubly terminated all-pole LC ladders filters, Synthesis of doubly terminated LC ladders with finite zeros of transmission. **Module-II:** Network sensitivity - low sensitivity of doubly terminated ladders, Introduction to frequency transformations, Properties of the driving impedance of lossless LC networks, Tellegen's theorem and positive real functions, Low Pass-to-Low Pass, Low Pass-to-Band Pass, Low Pass-to-High Pass and Low Pass-to-Band Stop transformations, Richard's Transformation, RC-CR transformation, Emulation of an inductor with a capacitor and controlled sources, the gyrator, a second order transconductor capacitor filter. [L-8] **Module-III:** Cascade of biquads realization of high order low pass filters, equivalence of the parallel RLC and series RLC circuits. Dynamic Range in active filters - impedance scaling and its effect on dynamic range, Introduction to noise in electrical networks, node scaling, Dynamic range scaling in active filters. [L-7] **Module-IV:** Biquad Ordering, Active Ladder Emulation / Leapfrog Filters, Effect of Transconductor non idelaities (parasitic capacitance/output resistance), parasitic poles, Effect of Finite Gain of the Transconductor. [L-5] **Module-V:** Single-ended Versus Differential Filters, Introducing the Differential-pair Based Fully Differential Transconductor, the Need for Common-mode Feedback, Stability of the Common-mode Feedback Loop, Common-mode Positive Feedback in Gyrators, Noise in the Differential Pair, Linearity of the Differential Pair, Cascoding, Noise in Cascodes, Layout Considerations and Multi-finger Transistors. Linearizing the Differential Pair, Resistive Degeneration. [L-7] **Module-VI:** Noise in Degenerated Transconductors, The Folded Cascode and Noise Analysis, Stabilizing filter bandwidth over process and temperature - the resistor servo loop, master-slave loops, Turning the filter into a VCO to estimate center frequency, example of a practical precision fixed-gm bias circuit, Introduction to accurate measurement and characterization techniques for active filters, Introduction to Active-RC filters, the use of an OTA instead of an opamp, swing and noise considerations, single stage OTAs, Multistage OTAs for use in CMOS Active-RC filters, The Miller compensated opamp in active-RC filters, noise considerations, noise in active-RC filters, Distortion and Intermodulation in filters, fixed gm-bias circuits [L-10]
Text Books, and/or Reference material	**Text Book**: 1. R Schaumann and M E Van Valkenburg, "Design of analog filters", First Edition, Oxford University Press, 2005. **Reference Books**: 1. G Daryanani, "Principles of active network synthesis and design", New York, Wiley, 1976. 2. M Van Valkenburg, "Analog filter design", New York, Holt Rinehart and Winston, 1982. 3. Franco S., "Design with operational amplifiers and analog integrated circuits", 3rd ed. New York, McGraw-Hill, 2002. 4. Allan Waters, "Active filter design", New York, McGraw-Hill, 1991. 5. Passive and Active Filters (Theory and Implementations) By: Wai-Kai Chen

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	2	1	2	2	1	1	1	1	1	2	3	2
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE616	VLSI Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BasicElectronics (ECC01), PhysicsofSemiconductor Devices (PHC331)		CT+MT+EA					
Course Outcomes	CO#1: Outline basic knowledge of semiconductor materials, devices and growth process of Si devices CO#2: Identify the process flow of device fabrication. CO#3: Illustrate the each process method of VLSI technology CO#4: Build the knowledge of integrated process technology						
Topics Covered	**Module1: Introduction**[3L] Materials,Definitions,Scalinglaws,IdeaofCleanroom,SiSubstrate Growth and Cleaning of Si **Module2: Oxidation** [5L] Oxidation:ProcessofOxidation,TypesofOxidation,Deal-GroveModel,Dependenceof oxidationondifferentparameters,ApplicationsinICtechnology,LOCOS. **Module3: Lithography**[6L] Processflowoflithography,ComponentsofLithography,Aligner; Contact,Proximity,Projection,MetricsofLithography,Photoresist-PositiveandNegative, Mask,Nextgenerationlithography. **Module4: Diffusion and Ion Implantation** [7L] BasicConcepts,DiffusioninSi,PolySi,BasicProcess:Pre-deposition andDrive-inDiffusion,ProblemsinThermalDiffusion,AdvantagesofIonImplantation, IonImplantationsystem,Mechanism,ImplantationProfile,JunctionDepth, DoseandConcentration relationship,IonImplantationdamageandannealing,Ion Channeling,MultiImplantation.						

	Module5: ThinFilmDeposition[6L] Requirementsofdeposition,Methods:PhysicalVaporDepositionandChemicalVapordeposition,StepCoverageandFillingIssues. **Module6Etching:**[3L] Etchprocess,Requirements,Figureofmerits,TypesofEtch,DryandPlasmaEtch,IonenhancedEtch. **Module7: Metallization and Interconnect**[6L] Interconnect,Interconnectrequirements,PossibleInterconnectmaterials,Al metallization,Alspikeproblem,HillocksandVoids,ElectromigrationProblems,Methods toreducetheproblems,Metalsilicides,MultilevelMetallization,Wplugsforcontactand vias,IntermetalDilectrics. **Module8: ICprocessIntegration**[6L] SimpleResistor,Capacitor,NMOS.
Text Books, and/or reference material	1.VLSITechnology: SMSze 2.SiliconProcessTechnology: SKGandhi 3.SiliconVLSITechnology:Plummer,DealandGriffin 4.FundamentalofSemiconductorFabrication:SzeandMay

COURSE ARTICULATION MATRIX

Mapping CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

CO \ PO/PSO	PO#1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO# 2	PSO# 3
CO#1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO#2	1	2	1	1	1	1	1	1	1	2	1	1	2	2	1
CO#3	2	3	2	2	3	1	2	1	1	2	1	2	3	3	2
CO#4	3	1	3	3	2	1	1	1	2	2	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE617	Probability and Random Signal Theory	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT),End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Characterize probability models and function of random variables. • CO2: Evaluate and apply moments, ACF, PSD & characteristic functions and understand the concept of inequalities and probabilistic limits. • CO3: Recognize, interpret and apply a variety of deterministic and nondeterministic random processes that occur in engineering.						

Topics Covered	1. Introduction: Basic of Probability theory, Bernoulli's Trials (5L) 2. Random Variables: types, examples, PDF, PMF, Conditional probability density function, (10L). 3. Function of one random variable. (4L) 4. Mean, Variance, Moments, Characteristics functions of random variables (5L) 5. Two random variables, Joint density and distribution function, one function of two random variables, Two functions of two random variables (8L) 6. Random processes: definitions and notations, Autocorrelation function, Cross correlation function, Covariance, PSD, Markov Processes, Gaussian Process, Poisson Process, Systems and random signals (10L)
Text Books, and/or reference material	**Text Books**: 1. A. Popoulis, U. Pillai, *Probability, random variables and stochastic processes*, Tata McGraw-Hill Inc., 4th Ed., New Delhi, 2017 2. K. Sam Shanmugam, *Digital and analog communication systems*, Wiley, India, 2011. 3. P. Peebles, *Probability, random variables and random signal priniciples*, McGraw-Hill Inc., 4th Ed., New York, USA, 2001 4. C. W. Therrien, M. Tummala, *Probabilty and random processes for electrical and computer engineers*, 2nd Ed., CRC press, printed in India, 2012 **Reference Books**: 1. George R. Cooper, C. D. McGillem, *Probabilistic methods of signal analysis and system analysis*, Oxford University Press, 3rd Ed. , New Delhi, 2007 2. Alberto Leon-Garcia, *Probability and random processes for electrical engineering*, Pearson Education Inc., 2nd Ed., 2007

COURSE ARTICULATION MATRIX

Mapping the Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO#1**	**PO#2**	**PO#3**	**PO#4**	**PO#5**	**PO#6**	**PO#7**	**PO#8**	**PO#9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO#2**	**PSO #3**
CO#1	3	3	2	2	1	1	1	-	1	1	2	3	3	1	2
CO#2	3	2	2	2	2	-	-	-	-	1	1	1	3	2	2
CO#3	3	2	2	3	2	-	-	-	-	-	-	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 44				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE618	Data Communication and Computer Networks	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and End Assessment (EA))
Analog Communication (ECC401), Digital Communication (ECC501)	The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.
Course Outcomes	CO1: **Understand** the rudiments of how computers communicate CO2: **Acquaintance** with the architecture of a number of different networks CO3: **Understand** the principles of protocol layering CO4: **Understand** the basic aspects of packet based protocol design and implementation

	CO5: **Analyze** and **Explain** the information flow in network traffic CO6: **Interpret** the importance of interconnection networks
Topics Covered	**Course Introduction and Physical Layer – [4L]** Data communication; Networks; Protocols and standards; Layered tasks; OSI Model; TCP/IP protocol suite; Addressing; Physical layer and media; Data and Signals; Analog and Digital; Transmission impairment; Line coding; Block coding; Sampling; Modulation of digital data; Telephone modems; Modulation of Analog signals; FDM,WDM,TDM, Guided media; Unguided media; Circuit switching; Telephone networks; DSL technology; Cable modem; SONET. **Data Link Layer, Framing, and Error Handling– [8L]** Types of errors; Error detection; Error correction; Flow and error control; Stop and wait ARQ, go back N ARQ, Selective Repeat ARQ; HDLC; Point to Point protocol; random access; Controlled access; Traditional Ethernet; Fast Ethernet; Gigabit Ethernet; IEEE802.11; Bluetooth; Backbone network; Virtual LAN; Cellular Telephony; Satellite Networks; Virtual Circuit switching; Frame relay; ATM. **Queuing Analysis in Communication Networks– [10L]** Introduction to queuing models; Little's theorem; M/M/1,M/M/m queues; Networks of queues; M/G/1 queues; M/G/1 queues with occupancy distribution; M/G/1 queues with vacations, reservations, Priority queues; Stability of queuing systems; Multiple access and ALOHA; Stabilized ALOHA; Tree algorithms; CSMA, CSMA/CD and Ethernet **Network Layer Concepts – [5L]** Internetworks; Addressing; Routing; ARP; IP; ICMP; IPV6. **Transport Layer Concepts– [5L]** Process to process delivery; User Datagram Protocol (UDP); Transmission Control Protocol (TCP); Data traffic; Congestion control; Quality of Service(QoS); Integrated services; Differentiated services; QoS in switched networks **Routing and Flow Control– [8L]** High speed LANs; Token rings; Introduction to Switch Architecture; High speed switch scheduling; Broadcast routing and spanning trees; Shortest path routing; Distributed routing algorithms; Optimal routing; Flow control window/credit schemes; Flow control rate based schemes; ATM networks. **Application Layer, WWW and HTTP – [4L]** Domain Name System, Dynamic Domain Name System; Encapsulation; Remote Logging; Electronic mail and File transfer; HTTP architecture; Simple Network Management Protocol (SNMP); Multimedia; Digitizing Audio and Video; Audio and Video compression; Streaming stored Audio/Video; Streaming live Audio/Video; Real time interactive Audio/Video; RTP; RTCP; Voice over IP.
Text Books, and/or reference material	**Text Books**: 1. Ferouzan, Behrouz A., "Data Communications and Networking", TMH. 2. William Stallings, "Data and Computer Communication", Pearson Education. 3. Bertsekas, Dimitri, and Robert Gallager, "Data Networks", Upper Saddle River, NJ: Prentice Hall **Reference Books**: 1. Tanenbaum , A.S., "Computer Networks", Upper Saddle River, NJ: Prentice Hall 2. Black, Ulylers D., "Data Communication and Distributed Networks", PHI.

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	1	2	1	2	2	1	2	1	2	2	2	2	1

CO#2	2	2	2	2	1	1	1	1	1	1	2	3	2	2	2
CO#3	2	2	2	2	1	1	1	1	1	1	2	3	1	2	2
CO#4	2	2	2	2	1	1	1	1	1	1	2	3	1	2	2
CO#5	3	3	3	3	2	2	2	1	1	1	1	2	2	3	3
CO#6	3	3	3	3	2	2	2	1	1	1	1	2	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE619</td><td>Mobile Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Data Communication and Computer Networks (ECE618)</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduce to the basic of Wireless Networks.
• CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things.
• CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems.
• CO4: Able to understand the innovation opportunity in IoT application segments.
• CO5: Hands-on experience on Wireless Networks & Mobile Computing.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Physical Layer (6 Hours)
Bit transmission over Wireless, Vary Much different from Wired Network.
Module 2: Mac Layer (8 Hours)
Access in Shared Medium, Difference between Wired MAC & Wireless MAC, Different Type of MACs (a) Random MAC (b) Scheduled MAC, Examples of MAC Implementation (WiFi Protocol --802.11, Bluetooth Protocol--805.15).
Module 3: Network Layer (8 Hours)
Reactive Routing, Proactive Routing, DSR Principle, AODV Principle, Location Aware Routing. Adhoc Network, Delay Tolerant Network, Opportunistic Network Introduction, Architecture & Applications, Routing Algorithms – Epidemic, Prophet, Spray & Wait, Spray & Focus, Maxprop Simulation Tool - ONE Simulator.
Module 4: Transport Layer (8 Hours)
Wireless TCP and rationale, Difference between Wired TCP and Wireless TCP, QoS Measurement of Wireless Networks.
Module 5: Modelling (8 Hours)
Mathematical Modelling of Network Functionalities - Combining them to derived overall performance.
Module 6: Case Study: Implementation of opportunistic Networks in Challenged Network scenarios (4 hours)
(a) Connection Mechanism (b) Sync - Transferring the information in Collaborative manner (c) Offline Dashboard (Information Summarization) (d)security</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. “Mobile Communication”, by Jochen Schiller (PEARSON EDUCATION LIMITED).
2. “Wireless Networking” A kumar, D. manjunath, J. Kuri, Elsevier, 2008.
3. “Wireless Communication”, T. S. Rappaport, Pearson, latest edition.</td></tr>
</table>

	Research Papers: 1. IEEE Infocom Tutorials slides by Prof. NitinVaidya. **Others:** Tools: ● Sniffer Tool (Wireshark) ● Simulation Tools: OMNET ONE NS3

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#2	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3
CO#3	3	2	3	3	3	2	2	1	-	3	3	2	3	3	3
CO#4	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#5	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE620	Nanoelectronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
Electronic Devices and Circuits (ECC302), Physics of Semiconductor Devices (PHC331)		CT+MT+EA					
Course Outcomes	● CO1: Understand state of the art in semiconductor device physics and materials technology to enable the Nano-Electronics. ● CO2: Apply the fundamentals of classical CMOS technology. ● CO3: Implement the scaling of MOSFET in the sub-100nm regime. ● CO4: Apprehend the need of non-classical transistors with new device structure and Nano-materials.						
Topics Covered	**Module I: (L – 4)** Introduction to nanotechnology, the size of things, history of nanotechnology, fabrication method (top-down and bottoms-up), emerging applications of nanotechnology **Module II: (L – 8)** Electronic and Optical properties of nanostructures. Energy sub-bands. Electron						

	transport in two –dimensional electron gas (density of states), Carrier scattering, resistance of a ballistic conductor, Transmission probability calculation, Electron tunneling, Resonant tunneling, Coupled nanoscale structures and Super lattices. **Module III: (L – 10)** Shrink-down approaches: Electronic devices Based on Nanostructures: Advance Heterostructure Devices, Downscaling of the MOSFET. Nanoscale FET Transistors, the Ballistic FET, Resonant Tunneling Devices and Circuits, Single Electron Transistor and Related Devices. Devices based on carbon nanotubes, Spintronic Devices. **Module IV: (L – 10)** Optoelectronic Devices using Nanostructures: Quantum well and Quantum Dot LASERS, Quantum Cascade LASER, Quantum well infrared photo detector, Super lattice LASER. **Module V: (L – 10)** Nanotechnology: Deposition techniques for Nanoscale Devices, Nanolithography, Self-Assembly Techniques, Nanomaterials, Nanoparticles, Nanowires, Nanomagnetic Materials, Nanostructure Surfaces; Instrumentation for nanoscale electronics: The Atomic Force Microscope (AFM), Scanning Tunneling Microscope and scanning near field optical microscope.
Text Books, and/or reference material	1. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens,Wiley (2003). 2. Nanoelectronics and Information Technology (Advanced Electronic Materials and Novel Devices), WaserRanier,Wiley-VCH (2003). 3. Nanosystems, K.E. Drexler, Wiley (1992) 4. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998. 5. Fundamentals of Modern VLSI Devices, Y. Taur and T. Ning, Cambridge University Press. 6. “Nanoelectronics and Nanosystems,” Karl Goser, Springer, 2004

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	-	-	-	-	-	-	3	3	2	2
CO#2	2	2	3	2	3	-	1	-	-	-	-	2	2	3	2
CO#3	2	2	3	2	1	-	-	-	-	-	-	2	3	2	2
CO#4	2	3	2	3	3	2	1	1	-	-	-	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE621	Measurement and Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
None		CT+MT+EA					

Course Outcomes	CO#1: Understand characteristics of general measurement system CO#2: Apply qualitative analysis techniques in general measurement system CO#3: Apply quantitative analysis techniques in general measurement system CO#4: Understand basic building blocks of general measurement system CO#5: Design general measurement systems with functional blocks CO#6: Investigate complex designs in measurement systems with functional blocks
Topics Covered	1. General measurement system, Static and dynamic characteristics of measurement systems [8L] 2. Loading effect, two port network model of measurement systems, signal noise [6L], 3. Reliability, Choice and Economics of Measurement Systems [3L] 4. Lagrangian dynamics [4L] 5. Sensing elements [6L] 6. Signal conditioning and Processing, Data presentation [6L] 7. Case studies in measurement system: [9L]
Text Books, and/or reference material	**Text Books**: 1. Principles of Measurement Systems, John Bentley, 3rd Edition. **Reference Books**: 1. Mechatronics, A. Preumont. 2. Electronic Instrumentation and Measurements, David A. Bell, 3rd Edition.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	2	3	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	1	1	2	3	1	1	1	1	1	1	1	1	2	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE622</td><td>Digital IC Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous (CT), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="3">Digital Circuits and Systems (ECC402)</td><td colspan="5">Assignments, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">At the end of the course, a student will be able to:
CO#1: Understand the characteristics of CMOS inverter and interconnects.
CO#2: Study the Static and dynamic characteristics of MOS inverter
CO#3: Learn the basic steps of ASIC and fabrication process.
CO#4: Analyze the performance of CMOS inverter circuits.
CO#5: Illustrate the combinational and sequential logic circuits
CO#6: Understand the recent trends in VLSI Design & its research issues in industry/ academia</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module-I: (L – 3)
Overview of VLSI Design: Historical perspective, overview of VLSI design methodologies, VLSI design flow, design hierarchy, concepts of regularity, modularity, and locality, VLSI design styles, design quality, packaging technology, CAD technology, ASIC Design flow.
Module-II: (L – 6)
Fabrication of MOSFETs:Fabrication process flow- basic steps, the CMOS n-Well process, layout design rules, stick diagram, full-custom mask layout design.
Module-III: (L – 6)
MOS Transistor: The metal oxide semiconductor (MOS) structure, MOS system under external bias, structure and operation of MOS transistor (MOSFET), MOSFET current-voltage characteristics, MOSFET scaling and small-geometry effects, MOSFET capacitances.
Module-IV: (L – 4)
Modelling of MOS Transistors: Basic concepts, state-of-art MOSFET models, capacitance models, comparison of SPICE MOSFET models.
Module-V: (L – 4)
MOS Inverter (Static Characteristics): Resistive-load inverter, inverter with n-type MOSFET load, CMOS inverter.
Module-VI: (L – 4)
MOS Inverters (Switching Characteristics and Interconnects effects): Delay-time definitions, calculation of delay times, logical efforts, inverter design with delay constraints, estimation of interconnect parasitics, calculation of interconnect delay, Bus vs. Network-on-Chip (NoC), switching power dissipation of CMOS inverters.
Module-VII: (L – 5)
Combination CMOS Logic Circuits: MOS logic circuits with depletion nMOS loads, CMOS logic circuits, complex logic circuits. CMOS transmission gates (pass gates).
Module-VIII: (L – 5)
Sequential MOS logic circuits:Behavior of bistable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch and edge-triggered flip-flop.
Module-IX: (L – 5)
Dynamic logic Circuits: basic principle of pass transistor circuits, voltage bootstrapping, synchronous dynamic circuit techniques, dynamic CMOS circuit techniques, high-performance dynamic CMOS circuits.</td></tr>
</table>

Text Books, and/or reference material	**Text Book**: 1. CMOS Digital Integrated Circuits, Sung-Mo Kang,YusufLeblebici, 3rd edition, Tata McGraw-Hill, 2003 **Reference Books**: 1. J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, 2nd Edition, Prentice Hall 2004. 2. N. H. E. Weste and C. Harris, "Principles of CMOS VLSI Design: A System Perspective, 3rd Edition, Pearson Education 2007.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO #3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	2	1	2	2	1	1	1	1	1	2	3	2
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE623	Mechatronics Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT),End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: **Understand** characteristics of mechatronics system • CO2: **Apply qualitative analysis** techniques in mechatronics system • CO3: **Apply quantitative analysis** techniques in mechatronics system • CO4: **Understand** basic building blocks of general mechatronics system • CO5: **Design** general mechatronics system with functional blocks • CO6: **Investigate complex designs** in mechatronics system and case studies						
Topics Covered	Introduction to mechatronics [1L] Sensors and Transducers, Pneumatic and Hydraulic, Mechanical Actuation Systems, Electrical actuation systems [8L] Signal Conditioning circuits [4L] Digital Processing Elements [3L] Data Presentation Systems [2L] System models and Dynamic response [3L] System Transfer functions and frequency response [3L]						

	Closed loop controllers [2L] Artificial Intelligence [2L] Microcontrollers and programming [4L] Interfacing and communication [2L] Case studies [8L]
Text Books, and/or reference material	**Text Book**: 1. Mechatronics, by W. Bolton, Fourth Edition, Pearson

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	2	3	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	1	1	2	3	1	1	1	1	1	1	1	1	1	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE624	Power Electronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))					
Basic Electronics (ECC01), Signals and Systems (ECC303)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	• CO1: To learn the details of power semiconductor switches (Construction, Characteristics and operation) and working of various types of converters. • CO2: To learn how to analyse the converters and design the components of them, under various load types. • CO3: To learn about the control of various converters. Recognize the role power electronics play in the improvement of energy usage efficiency and the applications of power electronics in emerging areas.						

Topics Covered	**Module-1 (**duration- 4 hrs) Introduction: Application of Power Electronics to : 1) Motor control with emphasis on Traction and Industrial Process control 2) Power Supplies - Revolution in Personal Computers UPS 3) Power Transmission - Facts Technology, HVDC 4) Chemical Process 5) Battery charging 6) Power extraction from non-conventional enery sources 7) Automotive electronics 8) High energy physics Evolution of Power Electronics Days of Mercury arc rectification--forerunner of Power Electronics Invention of SCR and its impact Advent of Self-commutated switches and their impact **Module-2 (**duration-4hrs) Structure of Power Electronics: How structurally power electronics differs from low power analog electronics Different types of switches Power Diodes: from the viewpoint of an application engineer SCR: Device structure, Static characteristic, dynamic characteristic constraints of Turn on and Turn off time, different relevant ratings. **Module-3 (**duration-4hrs) Diode rectifiers Applications: Power Supplies, Front end converter for ac motor drives, battery charger, chemical process 1) Single phase Half wave with R load 2) Single phase Half wave with R-L load 3) Single phase Full bridge rectifier with dc link capacitive filter, issue of harmonics 4) Three phase Full bridge rectifier with dc link capacitive filter, issue of harmonics **Module-4 (**duration-5hrs) AC to DC controlled converters Application: DC Motor Drives Battery chargers HVDC transmission 1) Single phase fully controlled AC to DC converter i) Principle of operation: Issue of line commutation ii) Continuous mode of conduction: expression for average output voltage iii) Modes of operation in the voltage-current plane iv) discontinuous mode of conduction v) analysis with R-L-E load, significance of R-L-E load vi) operation as an inverter: constraints for line commutation vii) Dual converter: motivation Simultaneous and nonsimultaneous control vii) input displacement factor, distortion factor, harmonics viii) Effect of source inductance ix) Requirement of snubber 2) Single phase half controlled converter: operating principle, input displacement factor Modes of operation in the voltage-current plane Modes of operation in the voltage-current plane **Module-5 (**duration-2 hrs) Three phase half wave ac to dc converter Principle of operation Derivation of o/p voltage issue of dc magnetization of the input transformer **Module-6 (**duration-3 hrs) Three phase fully controlled ac to dc converter

	Principle of operation Derivation of average output voltage Derivation of displacement factor Inverter mode of operation Constraints of commutation in inverter mode Effect of source inductance **Moduel - 7 (**duration-4 hrs) Limitation of Line commutated converters Single phase unity powerfactor converter Principle of switched Power power conversion Bi-directional Power converters **Module- 8 (**duration-8 hrs) DC- DC Power Converters Limitations of Linear Power supplies Switched Power Power supplies (Buck, Buck-Boost, Boost, Cuk, Fly-back and Forward Convverters) Transfer fucntion for these converters **Module-9 (**duration-8 hrs) Motivation DC- AC Power Converters Principle of operation of Inverters Half bridge, full bridge, three phase- six step operation, voltage control, PWM techniques
Text Books, and/or reference material	**Text Books:** 1. M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI Third Edition, New Delhi, 2004. 2. P.S.Bimbra "Power Electronics" Khanna Publishers, third Edition, 2003. 3. L. Umanand, " Power Electronics Essentials and Applications", Wiley, 2010. **Reference Books:** 1. Joseph Vithayathil, 'Power Electronics, Principles and Applications', McGraw Hill Series, 6th Reprint, 2013. 2. Ashfaq Ahmed Power Electronics for Technology Pearson Education, Indian reprint, 2003. 3. Philip T. Krein, "Elements of Power Electronics" Oxford University Press, 2004 Edition. 4. Ned Mohan, Tore. M. Undel and, William. P. Robbins,' Power Electronics: Converters, Applications and Design', John Wiley and sons, third edition,2003. 5. Daniel.W.Hart, "Power Electronics", Indian Edition, McGraw Hill, 3rd Print.

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome(PSO)															
PO / PSO CO	**PO# 1**	**PO# 2**	**PO# 3**	**PO# 4**	**PO# 5**	**PO# 6**	**PO# 7**	**PO# 8**	**PO# 9**	**PO# 10**	**PO# 11**	**PO# 12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	2	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	3	1	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE625</td><td>Optical Communication</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="2">Electromagnetic Theory and Transmission Lines (ECC403),
Analog Communication (ECC401),
Digital Communication (ECC501)</td><td colspan="6">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO#1 Students will be able to understand circuits and system level implementation in lightwave technology.
CO#2 The students can design components and choose appropriate sources and receivers for an optical network.
CO#3 Understanding the usage of OTDR in monitoring an optical communication system.</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Introduction to fiber optics, principles of optical fiber; Advantages. Elements of an optical fiber transmission link. [4L]
Optical fiber characteristics, types of optical fibers; Attenuation and Dispersion in optical fiber: Signal attenuation and distortion in optical fibers, Dispersion effects in optical fibers.; OTDR [10L]
Optical Sources: Structure and materials of LED and LD sources operating characteristics and modulation capabilities of the LED and LD sources. Source to Fiber Power launching and coupling, Lensing schemes for coupling improvement, Fiber to fiber couplings and alignment methods, Splicing techniques, Fiber Connectors. [8L]
Optical Receiver: Optical receiver configuration and performance, Pre-amplifier design for optical receiver, analog and Digital receiver. Point to point transmission links, Wavelength division multiplexing, Optical data buses, Link power and rise time budget, Optical Amplifier. [8L]
Optical Networking: Fiber optics in LAN, MAN, SAN, WAN, FDDI architecture, SONET/ SDH architecture, SONET/ SDH network elements [8L]
Potential applications and future prospects of optical fibers, multimode intensity sensors and single mode, Interferometric sensors; Free space optical communication [4L]</td></tr>
<tr><td>Text Books, and/or Reference material</td><td colspan="7">Text Books:
[1] J. M. Senior, “Optical Fiber Communications”, PHI, 2nd Ed.
[2] G. Keiser, “Optical Fiber Communication”, McGraw Hill, 3rd Ed.
[3] Ghatak &Thyagarajan, “Introduction to fiber Optics”, Cambridge University press.
[4] Henry Zanger and Cynthia Zanger, Fiber Optics Communication and Other Application, Macmillan Publishing Company, Singapore 1991.
Reference Books:
[1] J.H.Franz&V.K.Jain, “Optical Communications”, Narosa Publishing House.
[2] Ghatak &Thyagarajan, “Contemporary Optics”, Series Title: Optical Physics and Engineering, Springer
[3] AmnonYariv and PochiYeh, Photonics: Optical electronics for Modern Communication, 6th Ed., New York, Oxford University Press</td></tr>
</table>

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO / PSO CO	**PO# 1**	**PO# 2**	**PO# 3**	**PO# 4**	**PO# 5**	**PO# 6**	**PO# 7**	**PO# 8**	**PO# 9**	**PO# 10**	**PO# 11**	**PO# 12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	2	2	2	3	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	Principles of Management	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1:To make budding engineers aware of various management functions required for any organization • CO2:To impart knowledge on various tools and techniques applied by the executives of an organization • CO3:To make potential engineers aware of managerial function so that it would help for their professional career • CO4:To impart knowledge on org. activities operational & strategic both in nature • C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science						
Topics Covered	**UNIT I:** Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization **(8L)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique **(7L)** **UNIT III:** Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. **(8L)** **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. **(8L)** **UNIT V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. **(12L)**						
Text Books, and/or reference material	**Text Books**: 1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. 2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education 4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 5. Operations Management, 7th ed.(Quality control, Forecasting), Buffa&Sarin, Willey						

COURSE ARTICULATION MATRIX

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	-	-	-	-	-	-	-	-	3	2	2	-	2	1	1
CO#2	-	-	-	2	-	-	-	-	2	2	-	-	2	1	1
CO#3	-	-	-	2	-	-	-	-	3	2	-	-	2	1	1
CO#4	-	-	-	-	-	-	1	-	3	-	-	-	2	1	1
CO#5	-	-	-	2	-	-	-	-	2	2	2	-	2	1	1

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 30</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS751</td><td>Computer Aided Design Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">VLSI Design Lab (ECS652)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">

CO1: Employ CAD tools to carry out Analog IC Design using bottom up approach
CO2: Illustrate NMOS and PMOS transistor and its use in Analog Circuit Design
CO3: Design common source amplifier to meet any given specification.
CO4: Design and implementation of various components of a processor.
CO5: Evaluate the performance of VLSI Designs.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of experiments:

Plot the NMOS I/V characteristics and measure its VT, $\mu_N C_{OX}, g_m, f_T$ at the DC bias point of $V_{DS} = 0.5\ V$, and $V_{GS} = 0.4\ V$. Also determine the corresponding values for PMOS transistor at $V_{DS} = 0.6\ V,\ V_{GS} = 0.5\ V$
For an NMOS with W/L = 500n/500n, plot $g_m, \frac{g_m}{I_D}, V_T, f_T, r_{out}$ and self-gain by sweeping $0 < V_{GS} < 1V$ for $V_{DS} = 0.3\ V, 0.5\ V and\ 0.9\ V$. Interpret the results.
Simulate the VTC of pseudo-NMOS inverter so that $V_M = 0.5\ V_{DD}$. Now measure the Noise margins and t_{PLH}, t_{PHL} when CL = 1 pF. Also, measure the static power and dynamic power dissipation when the clock frequency is 10 MHz.
Design a CMOS Common Source Amplifier with PMOS active load from a min. gain of 20 dB. Plot its frequency response when a load of 1 pF is connected. Measure its power dissipation (PD).
Design and implementation of ALU and ALU Controller for MIPS processor.
Design and implementation of Sequence Controller for MIPS processor.
Design and implementation of Multiplexer and Program Counter for MIPS processor.
Design and implementation of Concentration, Combinational and shift-by-2 modules for MIPS processor.
Design and implementation of RAM and Register files for MIPS processor.
Design and implementation of State Register and Sign-Extend Modules for MIPS processor.
</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">

B. Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw-Hill Education, 2002.
Allan Hastings, “The Art of Analog Layout”, Prentice Hall, Second Edition, 2005.
N. H. E. Weste and C. Harris, “Principles of CMOS VLSI Design: A System Perspective”, 3rd Edition, Pearson Education 2007.
</td></tr>
</table>

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	2	1	1	1	1	1	1	1	1	1	2	2	2
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	2	2
CO#3	3	3	3	1	2	2	1	1	1	1	1	1	3	3	2
CO#4	1	2	1	1	1	1	1	1	1	1	1	1	2	2	2
CO#5	2	3	1	2	2	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 40				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS752	Electronic System Design Lab	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Electronic Devices andCircuits I, II (ECC302, ECC504), Electrical Technology (EEC01)		CT+EA					
Course Outcomes	• CO1: Understand experimental design procedure • CO2: Develop troubleshooting techniques • CO3: Design electronic systems focusing on application • CO4: Develop skill to use modern engineering software tools • CO5: Develop technical report writing skill • CO6: Develop team activity for executing projects						
Topics Covered	• Introduction to electronic system design 1. Induction class on System Design, Fabrication and Troubleshooting • Power supply design 2. Application of different types of batteries 3. Regulated DC power supply design • Experiments with Sensors and Actuators 4. LDR, Phototransistor, Piezoelectric elements, Hall sensor, inductive pickup 5. DC motor and BLDC motor driving, solenoid actuator. Speed control of motor using PWM, Servo motor, SMA actuator • Design of signal conditioning circuits 6. Electronic signal amplifier, Instrumentation amplifier design 7. Low pass, High pass, Band pass, Band stop Filter design • Design of signal processing systems 8. Introduction to microcontrollers 8052/Arduino/Raspberry pi 9. Data acquisition via microcontrollers and interfacing with Matlab • Integration of data presentation elements 10. Interfacing display unit with microcontrollers 11. Data presentation using GUI						
Text Books, and/or reference material	TEXT BOOKS 1. Principles of Measurement Systems, John Bentley, Pearson 2. Electronic Circuits: Analysis and Design by Donald A Neamen 3. Mechatronics, by W. Bolton, Fourth Edition, Pearson 4. Digital Fundamentals by Floyd 5. Laboratory Experiments manual						

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	2	1	1	1	-	-	-	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	-	-	-	1	1	1	1	3	2	1

CO#3	1	2	3	1	1	-	-	-	1	1	1	1	1	3	2
CO#4	1	2	1	1	3	-	-	-	1	1	1	1	3	2	1
CO#5	1	1	1	1	1	1	1	2	1	3	1	1	3	2	1
CO#6	1	1	1	1	1	1	1	1	2	1	2	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 18				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS753	Advanced Communication Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	On successful completion of this course, students should have the skills and knowledge to: CO#1. Understand Monte Carlo Simulation of Discrete and Continuous random variables CO#2. Estimate Bit Error Rate (BER) of a Communication Systems CO#3. Evaluate the performance of simple modulation over AWGN and Fading Channel (typically Rayleigh and other) CO#4. Model fading channels and understand Digital Communication concepts in context to fading channels. CO#5. Assess the performance of simple Network Access protocols like ALOHA and S-ALOHA by simulation. CO#6. Develop expertise in writing program using MATLAB and tools like SIMULINK.
Topics Covered/ Syllabus	1. Discrete Event Simulation : 1. (A) Generation of random variables. (a) Discrete (i) Poisson (ii) Binomial (iii) Geometric (b) Continuous (i) Gaussian (ii) Exponential (iii) Lognormal (iv) Rayleigh (v) Erlang (vii) Generate Gaussian from uniform distributed Random variable. Generate the r.v-s with suitable chosen parameters. 1. (B) Generate the PDF (probability density function) of the r.v-s by simulation. Match the simulated pdf with the corresponding analytical pdf-s. [show this for (b)i , b(iii) and b(iv) cases]. 2. (A) Simulation of AWGN channel and BER performance of BPSK. (Generate BPSK at baseband, Tx through a channel corrupted by Gaussian noise of a given noise var. Rx the signal bit, compare it with Tx bit and estimate BER via no. of iteration). Plot the BER vsEb/No. (B) Simulate Packet error rate (PER) in above for an arbitrary packet of size L = 500 bits. 3. Repeat the above Expt no.2 (a) for a Rayleigh faded channel. 4. Generate a PN sequence of (a) 15 bits (b) 31 bits. Simulate and plot the autocorrelation function of generated PN sequence. 5. Simulate the arrival process in a Poisson based arrival with typical mean arrival rate (for example 0.84 calls/sec.) Using above simulate Throughput for ALOHA and S-ALOHA protocol(s). 6. Simulation and Performance studies of QPSK and Offset QPSK (using MATLAB

	and SIMULINK)
Text Books, and/or Reference material	1. Simulation Modeling and Analysis : Law and Kelton McGraw-Hill 2. Simulation : Sheldon Ross, Academic Press 3. Contemporary Communication Systems : M.F. Mesiya McGraw-Hill India 4. Modern Communication Systems using MATLAB, John Proakis, MasudSalehi and Gerhard Bauch, Third Ediation, CENGAGE Learning

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	3	2	3	2	-	-	-	1	1	-	1	3	2	2
CO#2	3	3	3	2	-	-	-	-	-	1	-	1	3	2	2
CO#3	3	3	3	2	-	-	-	-	-	1	-	1	3	2	2
CO#4	3	3	1	2	1	-	-	-	1	1	-	2	3	2	2
CO#5	3	3	2	3	2	1	-	-	1	1	-	1	3	2	2
CO#6	3	2	2	2	3	-	-	-	2	1	-	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering

Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE710	Detection and Estimation Theory	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))
Probability Theory for Engineering Application (ECO541) / any equivalent content from NPTEL, SWAYAM etc.	CT+MT+EA

Course Outcomes	• CO1: To familiarize students with Classical Statistical Inference Techniques and their applications to Communication and Signal processing • CO2: To familiarize students with Signal Detection Theory • CO3: To develop required mathematical skills for design and implementation of statistical signal processing algorithm
Topics Covered	**Topic 1:Random Signal and Random Process Basics [5]** Important probability distribution functions: Gaussian, Chi-square, Rayleigh, Rician, Student's t, F, Cauchy etc. Bivariate and Multivariate Distribution Random Process, Correlation properties, Stationarity, Ergodicity, Gaussian Process, Power Spectral Density **Topic 2: Classical Decision Theory [10]** Introduction to signal detection problems

	Bayes Criterion: Binary Hypothesis testing, M-ary hypothesis testing Maximum Likelihood based Optimal detection, LRT (Likelihood Ratio Test) and performance. Neyman Pearson Criterion for optimal detection , Minimum probability of error detector, Minimax Criterion **Topic 3:Detection of Deterministic and random Signal[8]** Matched Filter Detection, Optimal detection for white and Nonwhite noise, Multiple Hypothesis testing, Estimator Correlator, Energy Detector **Topic 5: Detection of Signal with unknown parameters [6]** Composite Hypothesis Testing : Bayesian Approach and GLRT, Sinusoidal detection **Topic 6: Estimation Techniques [8]** Introduction to signal Estimation, Unbiased estimators, Minimum variance unbiased estimator (MVUE), MVUE Criterion, Cramer Rao Lower bound(CRLB), Best Linear Unbiased Estimator(BLUE), General CRLB for signals in white noise, Least Square Estimation and Recursive Least Square Estimation. **Topic 7:Random parameter Estimation**: [6] Bayesian Formulation, Minimum mean square error (MMSE) and MAP estimation,Linear MMSE estimation, Wiener and optimum MMSE Filtering
Text Books, and/or reference material	**Text Books:** 1.Fundamentals of Statistical Signal Processing, (Vol 1 &Vol 2) S.M. Kay, Pearson 2. Detection, Estimation, and Modulation Theory, Part-1, VanTrees, Jhon Wiley **Reference Books:** 1. Signal Detection and Estimation, Second Edition,MouradBarkatArtechhouse. 2. An Introduction to Signal detection and Estimation: H. Vincent Poor, Springer-Verlag

COURSE ARTICULATION MATRIX

Mapping of CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	1	1	1	1	1	1	1	3	2	2
CO#2	3	3	3	2	1	1	1	1	1	1	1	1	3	2	2
CO#3	3	3	3	2	1	1	2	1	1	1	1	1	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE711	Information Theory and Coding	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	**CO.1** Understand the concept of Information and quantitative from of characterization of information. **CO.2**Understand abstraction of digital information transfer and characterizestorage/transfer from mathematical viewpoint. **CO.3** Gain knowledge about techniques for information compression and its application **CO.4**Understand Channel Capacity and Shannon's Law on Information capacity. Appreciate information theoretic results as fundamental limits on performance ofCommunication systems. Analyze Capacity of Various Channels. **CO.5** Understand the fundamental difference between Source Coding theorem andChannel Coding theorem. **CO.6** Understand different approaches for error correction and suitability of theirApplication. Develop understanding of Block Coding.
Topics Covered	1.**Information Theory** : Introduction, Uncertainty and Information, Entropy, Relative Entropy, Mutual Information, Chain Rules, Differential Entropy , Properties of Differential entropy, Jensen's inequality, data processing Inequality. (9L) 2. **Source Coding**: Source Coding Theorem, Kraft Inequality, Optimal codes, Huffman Code, Shannon Fano Elias Coding, Lempel Ziv Coding, Rate Distortion function (8L) 3. **Channel Capacity and Coding** : Channel Models, Channel Capacity, Binary Symmetric Channel , Binary Erasure Channel, Channel Coding Theorem, Information Capacity Theorem, Shannon's limit, Gaussian Channel, Parallel Gaussian Channel. (10L) 4. **Error Control Coding**: Linear algebra fundamentals, Linear Block Codes, Generator matrix, Parity Check Matrix, Encoding and Decoding of linear Block Codes, Syndrome Decoding, Hamming Code, properties of linear Block Code, Cyclic Codes: Algebraic description, Encoding and Decoding of Cyclic codes , Convolution Codes: Definition, Encoding Trellis and State representation, , Viterbi decoding, Error probability, Viterbi Decoding. (15L)
Text Books, and/or reference material	1. Information Theory Coding and Cryptography, Third Edition, Ranjan Bose, McGraw-Hill Education Pvt. Limited. 2. Elements of Information Theory , Thomas M.Cover and Joy.A. Thomas, Wiley 3. Error Control Coding, Fundamentals and Application Shu Lin, Daniel J. Costello, Pearson, India 4. Error Correction Coding Mathematical Methods and application, Todd K. Moon, Wiley, India.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO#2	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO#3	3	3	3	2	1	2	1	1	1	1	1	1	3	3	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	3	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#6	3	3	2	3	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE712	Analog IC Design	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CA), Mid Term(MT) and End Term (ET))
Electronic Devices and Circuits I and II (ECC302, ECC504)	(CA+MT+ET=15+25+60=100)

Course Outcomes	**CO1:** Define various parameters/terms associated with MOS transistors and Analog IC design. **CO2:** Describe the operation of a MOS transistor /Amplifier/other fundamental blocks. **CO3:** Solve any given circuit using appropriate Large/Small Signal model equations. **CO4:** Evaluate various performance metrics such as gain/BW/Power dissipation/Input & output range etc. **CO5:** Analyze feedback circuit and determine its poles, zeros, gain margin & phase margin. **CO6:** Design a Single stage Amplifier/Differential Amplifier to meet the given specifications.
Topics Covered	**Module-I: Introduction to MOS** (L – 04) MOS Device Physics – General Considerations, Overview of CMOS technology, MOS I/V Characteristics, Short Channel Effects, Noise, Large Signal MOS Device models. **Module-2: Small Signal MOS Model**(L – 02) MOS Device Capacitance, Small Signal Device Models. Different trans-conductance (front gate : g_m, output: g_ds, back-gate:g_mb). Unity gain frequency calculation. **Module-3: Basic MOS Amplifiers**(L – 08) Single Stage Amplifiers – Basic Concepts, Common Source Stage, Source Follower, Common Gate Stage, Cascode Stage, Calculation of Amplifier parameters. **Module-4: Current Mirrors/References**(L – 03) Current Mirror: Simple, Cascode, Wilson, Wide-Swing. **Module-5: Frequency Response of Amplifiers**(L – 06) Frequency Response of Amplifiers – General Considerations, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage, Differential Pair. **Module-6: Differential Amplifier**(L – 07) Differential Amplifiers – Single Ended and double ended. Differential Operation, Basic Differential Pair, Common- Mode Response, Differential Pair with MOS loads, current mirror load. **Module-7: Single stage Opamps**(L –07) Operational Amplifiers – General Considerations, Single Stage Op Amps, Two Stage Op Amps, Input Range limitations(ICMR), Slew Rate, Noise and Offset in Op Amps. **Module-8: Feedback** (L – 05) Feedback-Types, Nyquist plot, Stability- Frequency compensation techniques, Miller compensation, pole splitting, Gain Margin, Phase Margin.
Text Books, and/or Reference	**Text Books:** [1] Design of Analog CMOS Integrated Circuits, by BehzadRazavi, McGraw-Hill, 2014. [2] Adel Sedra, Kenneth C. Smith, Tony Chan Carusone, Vincent Gaudet, " *Microelectronic Circuits*", Oxford, 8th Ed. 2020

material	[3] Understanding Microelectronics: A Top-Down Approach by Franco Maloberti, Wiley (2011) **Reference Books**: [1]. Analysis and Design of Analog Integrated Circuit, Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, John Wiley & Sons, Inc., 5th edition 2015 [2]. CMOS: Circuit Design, Layout, and Simulation by R. Jacob Baker, Wiley-IEEE Press(2019)
Video Lectures	**NPTEL/SWAYAM Video Lectures:** https://www.youtube.com/watch?v=2i2PMtRDvE8&list=PLuv3GM6-gsE0ix0s_d6JNIQXePzXr3_GZ Prof. NagendraKrishnapura, IITM https://www.youtube.com/watch?v=pK2elUcXWzs&list=PLiDoPUX9nLkIw9EnIv_3K19wlcyJ6msYd [3]. Prof. BehzadRazavi, UCLA

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO# 3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	2	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	1	1	2	2	1	1	1	1	1	2	3	1
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE713	FPGA based Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA: 15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))					
Digital Circuits and Systems (ECC402), VLSI Design (ECC602)		Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance					

Course Outcomes	●**CO1:** Learn logic synthesis techniques – two-level and multilevel synthesis. ●**CO2:** Be able to design systems using FPGAs and CPLDs. ●**CO3**: Learn sequential machine design using FPGAs. ●**CO4**: Learn to design systems for low power operation.
Topics Covered	**Module-I:** (L – 04) Logic design fundamentals: Two level synthesis – SOP/POS forms, Logic minimization, Limitations of two-level synthesis, introduction to multi-level synthesis. **Module-II:** (L – 06) Programmable Logic Devices: Programmable Logic Array (PLA) architecture; Programmable Array Logic (PAL), PAL vs. PROM, Fan-in expansion feature, Architecture for sequential circuit implementation, Typical PAL chips; Complex Programmable Logic Devices (CPLD). **Module-III:** (L – 06) Programmable Gate Arrays: Gate Array concept, Mask programmable and Field Programmable

	Gate Arrays; Lookup tables (LUT) Configurable logic blocks (CLB), logic design using LUT's; Multi-level synthesis techniques – Factoring and Functional decomposition, Shannon's Expansion Theorem; Generalized FPGA Architecture; Introduction to CAD Tools for FPGA based design, design entry, and simulation – introduction to HDL, synthesis, post-synthesis simulation, interfacing external devices. **Module-IV:** (L – 08) Sequential Circuit Design: Finite State Machines, Moore and Mealy Machines; State diagrams, State table, State assignment, derivation of next-state and output expressions, state minimization; State assignment for low power operation; CAD tools for FSM synthesis; Designing a simple CPU, concept of embedded system. **Module-V:** (L – 02) Advanced features of modern FPGAs: Block RAMs, Embedded processor, Communication ports, Analog interface. **Module-VI:** (L – 06) FPGA as a Hardware Debugging platform: Hardware troubleshooting methods, Looking into the chip – Logic State Analyzer and its use; Concept of Hardware emulation – simulation vs. Emulation, FPGA as a Hardware emulator, Break-points and their utility, setting break-points in FPGA based design. **Module-VII:** (P – 8) Familiarizing with CAD tools, Design and synthesis of simple logic functions – Basic gates, adder/subtractor, decoder, encoder, multiplexer, demultiplexer; Interfacing external devices – setting user constraint file, interfacing input (switch) and output (LED) devices, BCD to seven-segment decoder, keyboard/display interface; designing memory elements and arrays; sequential machine design – sequence generators, timing generators, a typical machine design (example: vending machine); A simple CPU design, constructing a basic embedded system – interfacing on-chip CPU, memory and I/O ports. **Module-VIII:** (P – 2) Design analysis: Static timing analysis, Power analysis, Resource utilization, noise, clock network, DRC, debugging methods.
Text Books, and/or Reference Materials	**Text Books**: 1. S. Brown and Z. Vranesic, "*Fundamentals of Digital Logic with Verilog Design,*" McGraw Hill Education Special India Edition (SIE), 2017. **Reference Book**: 1. J. Bhasker, "*A Verilog HDL Primer*", B.S. Publications, Hyderabad in arrangement with Star Galaxy Publishing, USA, 1999.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#2	2	2	2	2	1	2	1	1	1	1	1	1	3	2	2
CO#3	2	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#4	2	1	1	2	1	1	1	1	1	1	1	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE714	MEMS and Microsystems Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• CO1: **Understand** characteristics of MEMS system • CO2: **Understand** basic building blocks of general MEMS systems • CO3: **Understand** synthesis and fabrication of MEMS system • CO4: **Apply qualitative and quantitative analysis** techniques in general MEMS systems • CO5: **Design** techniques in MEMS • CO6: **Investigate complex designs** in MEMS systems
Topics Covered	Fabrication process (5L) Lumped Modeling, Statics, Dynamics (5L) Quasi static analysis (3L) Elasticity, Structures (4L) Energy Methods (3L) Thermal Energy Domain, Fluids, Electronics (6L) Noise (2L) Feedback systems (2L) Integration of MEMS systems, Scaling effect (3L) Reliability of MEMS devices (2L) Case studies in MEMS (7L)
Text Books, and/or reference material	**Text Book**: 1. Microsystem Design by Stephen D. Senturia, Springer **Reference Book**: 1. Micro and Smart Systems by K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre G.K. Ananthasuresh, Wiley

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#3	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO#4	1	3	2	1	1	1	1	1	1	1	1	1	2	3	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1	2	3	1
CO#6	1	2	3	1	1	1	1	1	1	1	1	1	2	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE715	Machine Learning	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: Continuous (CT), mid-term (MT), and End Assessment (EA)
Introduction to Computing (CSC01) & Computer Programming Languages like Python, C++, Matlab etc.	CT+MT+EA

Course Outcomes	After the completion of the course the student will be able to learn the following: • CO1: Distinguish between, supervised, unsupervised and semi-supervised learning • CO2: Apply the apt machine learning strategy for any given problem • CO3: Implement various ways of selecting suitable model parameters for different machine learning techniques • CO4: Modify existing machine learning algorithms to improve classification efficiency • CO5: Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues. • CO6: Study of various machine learning algorithms including deep learning
Topics Covered	**MODULE I INTRODUCTION [L=3]** Brief Introduction to Machine Learning, Supervised Learning ,Unsupervised Learning, Reinforcement Learning Design a Learning System, Perspectives and Issues in Machine Learning ,Concept Learning **MODULE II REGRESSION [L=6]** Linear Algebra, Statistical Decision Theory, Regression & Classification, Bias – Variance, Linear Regression, Multivariate Regression **MODULE III NEURAL NETWORKS AND SUPPORT VECTOR MACHINE[L=8]** Multi-layer Perceptron , Training of Multi -layer feed forward neural network using back propagation algorithm ,Over-fitting of trained model, Radial Basis Functions neural network, Support Vector Machines **MODULE IV TREE AND UNSUPERVISED LEARNING [L=7]** Learning with Trees , Decision Trees , Constructing Decision Trees ,Classification and Regression Trees , Unsupervised Learning, Gaussian Mixture Models, K-means clustering Algorithm **MODULE V DIMENSIONALITY REDUCTION [L=6]** Dimensionality Reduction, Linear Discriminant Analysis, Principal Component Analysis **MODULE VISTUDY OF MACHINE LEARNING ALGORITHMS[L=12]** Extreme learning machine (ELM), Training and testing of ELM, Recurrent Neural Network(RNN) and long short-term memory (LSTM),Training a LSTM based RNN, Reinforcement Learning, Deep learning and Convolutional Neural Network(CNN).
Text Books, and/or Reference material	**Text Books**: 1. StephenMarsland, “Machine Learning – An Algorithmic Perspective”, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014. 2. Tom M Mitchell, “Machine Learning”, First Edition, McGraw Hill Education, 2013.

	3.Satish Kumar, " Neural Networks: A Classroom Approach", McGraw-Hill (India), 2013 4.Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms, "Cambridge University Press",2014
	Reference Books: 1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", First Edition, Cambridge University Press, 2012. 2. Jason Bell, "Machine learning – Hands on for Developers and Technical Professionals", First Edition, Wiley, 2014 3. EthemAlpaydin, —Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series), Third Edition, MIT Press, 2014 4.Simon Haykin, "Neural networks and learning machines," Pearson,3rd edition,2009 5.Charu C.Aggarwal, "Neural Networks and Deep learning,"Springer,2018

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) & PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	2	1	1	2	1	1	1	1	1	1	2	3	2
CO#2	3	3	3	2	2	2	1	1	1	1	1	1	3	2	2
CO#3	3	3	2	2	2	1	2	1	1	1	1	1	3	3	2
CO#4	3	2	2	3	3	2	1	1	1	1	1	1	3	3	2
CO#5	3	2	2	2	2	2	1	1	1	1	1	1	3	2	2
CO#6	3	3	2	2	2	2	1	2	1	1	1	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE716</td><td>Millimeter wave Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods
(Continuous (CT), Mid-Term (MT) and End Assessment (EA))</td></tr>
<tr><td colspan="2">Electromagnetic Theory and Transmission Lines (ECC403),
Electronic Devices and Circuits I and II (ECC302, ECC504),
Microwave Engineering (ECC502)</td><td colspan="7">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO #1 Students will be able to learn the intricacies of design constraints at mm wave frequencies
• CO #2 The basic training for understanding circuit design at mm wave frequencies for our Country's defense and space applications would be enriched.
• CO #3 The students can design planar circuits and can provide reasoning for the obtained results.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Introduction: mm wave spectrum, Typical applications of microwave and mm wave, Safety considerations. Difference in High frequency and relatively low frequency behaviour of Lumped circuit components. Miniaturization and design of Lumped components at millimetre wave frequencies. Realization of reactive elements as mm wave planar circuit components. (2H)
Review of Transmission line theory. Concept of Scattering Matrix N-port networks-Properties of S matrix, Transmission matrix and their relationships (4H)
mm wave Waveguide and Resonators
Rectangular Waveguide- design consideration, TE and TM modes, TE_{10} mode analysis, cut-off frequency, propagation constant, intrinsic wave impedance, phase and group velocity, power transmission, attenuation, waveguide excitation, wall current; Introduction of circular waveguide; Rectangular waveguide resonator design consideration, resonant frequency, Q-factor, excitation. (6H)
Planar Transmission lines and Resonators at mm Waves
Propagation characteristics, comparison for different characteristics of the above mentioned lines. strip line, micro-strip line, coplanar waveguide, Slot line-design consideration, Substrate integrated waveguide, non radiating dielectric guides, Design synthesis and analysis (6H)
Passive Components and their S-matrix Representation
Millimetre wave passive components and their S matrix representation: Attenuators, Phase shifter, Directional coupler, Bethe-hole coupler, magic tee, hybrid ring, circulators, Isolators; design of planar power dividers and couplers; design procedure of filter using insertion loss method-specification, low-pass prototype design, scaling and conversion, implementation. (8H)
mm wave devices and Application to switches and mixers
TED (Gunn diode) & Avalanche Transit Time (IMPATT) device, Schottky diode, PIN & applications; Microwave bipolar transistor, Microwave field effect transistor. (6H)
Microwave Amplifier Design at mm Waves
Basic consideration in the design of microwave amplifier- transistor S-parameter, Stability,</td></tr>
</table>

	matching network, noise figure; matching network design using lumped elements and L-Section. Design of LNA. **(6H)** **mm wave measurement basics** VSWR meter, tunable detector, slotted line and probe detector, spectrum analyzer, network analyzer, measurement of VSWR – low, medium and high, measurement of power: low, medium and high, frequency measurement.**(4H)**
Text Books, and/or reference material	**Text Books:** [1] David. M. Pozar, *Microwave Engineering*, 2/e, 1998 (John Wiley & Sons). [2] DrDuixian Liu, Mr Brian Gaucher, Dr Ulrich Pfeiffer, DrJanuszGrzyb, *Advanced Millimeter-Wave Technologies: Antennas, Packaging and Circuits*, 2009 John Wiley & Sons, Ltd [3] G H Bryant, *Principles of microwave Measurement*, London : P. Peregrinus Ltd. on behalf of the Institution of Electrical Engineers, c1988 **Reference Books:** [1] P A Rizzi, *Microwave Engineering: Passive Circuits*, 2000, PHI [2] R E Collin, *Foundations of Microwave Engineering*, John Wiley and Sons India Pvt. Ltd. [4] Noël Deferm Patrick Reynaert, *CMOS Front Ends for Millimeter Wave Wireless Communication Systems*, Springer International Publishing Switzerland 2015

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE717	RFID Technology and Applications	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA)):					
Signals and Systems (ECC303) Analog Communication (ECC401) Digital Communication (ECC501) Microwave Engineering (ECC502) Analog IC Design (ECE712)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					

Course Outcomes	**CO#1** Ability to understand the basic knowledge of the radio frequency identification technology. **CO#2** Ability to analyze, explain and resolve technical problems related to RFID technology for skills. **CO#3** Develop an ability to forming, planning, deployment, operation, and evaluation systems using RFID technology and complete real models.
Topics Covered/ Syllabus	**Components Of RFID Systems And Performance Metrics**: Classification of RFID systems available, commercial specifications[L-6] **RFID Antenna and Tag Chip Design**:Design variants, developing matching elements, installation, environment [L-6] **Design of passive RFID tag**: Passive RFID Operation; Passive RFID Reader Design [L-6] **RFID Middleware**: Concepts and Architecture, Data Management and Application-Level Events [L-6] **TAG identification protocols**, Tree-Based Anti-Collision Protocols for RFID Tags, Comparison of TTF and RTF UHF RFID Protocols , Techniques of RFID Positioning[L-6] **Reader Infrastructure Networking**, Integrating RFID Readers in Enterprise IT, reducing interference in networks, Optimal Tag Coverage and Tag Report Elimination, Secure and Privacy-Enhanced RFID Systems, Cryptographic Approaches for Improving Security and Privacy Issues of RFID Systems [L-6] **Energy Harvesting for Self-Powered Autonomous RFID Systems**, Tag Architecture Based on Energy Harvesting, Simulators and Emulators for Different Abstraction Layers of UHF RFID Systems [L-6]
Text Books, and/or Reference material	**Text Books:** [1] R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi [2] Miles S,SarmaS,Wiiams J., (Eds.) (2008),RFID Technology and Applications, Cambridge: Cambridge University Press. Doi: 10.1017/CBO9780511541155 **Reference Book:** [1] M. Bolic, D. Simplot-Ryl, I. Stojmenovic (Editors), *RFID Systems: Research Trends and Challenges*, John Wiley and Sons, 2010.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO# 4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO#2**	**PSO# 3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electronics & Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE718</td><td>VLSI System Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))</td></tr>
<tr><td colspan="3">VLSI Design (ECC602)</td><td colspan="5">Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course, the student will be able to
• CO 1: Understand the full custom and semi-custom design flow.
• CO 2: Learn about static timing analysis and design constraints.
• CO 3: Understand the design for testability flows.
• CO 4: Identify and interpret the design towards realizing VLSI design.
• CO 5: Design and analyse the performance (speed, power) of VLSI circuits and design for different specifications.
• CO 6: Evaluate and design of memory cell.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I. Overview of VLSI System Design [L – 2]
VLSI System design methodologies, VLSI design flow, Recent Trends in VLSI Design & its research issues in the industry: System case studies. Design automation of VLSI Systems: basic concepts. Deep Sub-micron Technologies: Some Design Issues.
Module II. Full Custom Flow [L – 6]
Block specification, schematic design entry, netlist generation and simulation, simulation for process and operating corners, layout with DRC/ LVS clean, parasitic extraction for R & C, back annotation & simulation, simulation redone with parasitic information, Concepts of PCELL.
Module III. Constraints and Static Timing Analysis[L – 8]
Basic tenets of synchronous static timing: setup & hold timing, multipath & false paths, clock skew & latency, Asynchronous and synchronous clocks, crossing clock domains & clock gating; Design constraints for a design in SDC format: design objects, timing constraints, environmental constraints, case analysis; timing report, synchronous static timing.
Module IV. Semiconductor Memories[L – 8]
Memory hierarchy and types; SRAM Cell optimization and design metrics, memory read and write path; DRAM array design and related constraints, DRAM interface- address decoding, pipelining, data interface, charge pumps; non-volatile memory cell-basic principle and operation, reliability considerations of NVM; Case study- high-speed memory, low voltage memory.
Module V. Design for Testability[L – 8]
Introduction to DFT, DFT directory structure, DFT rule checker, debugging and fixing DFT violations, scan Mapping, Scan mapping, scan chain connection, using pre-compiled cores, adding testability logic, ATPG, DFT flows.
Module VI. Flow for Designing Full SoC [L – 5]
Block specification, schematic design entry, netlist generation and simulation, simulation for process and operating corners, layout with DRC/ LVS clean, parasitic extraction for R & C, back annotation & simulation, simulation redone with parasitic information, concepts of PCELL.
Module VII. Physical Design [L – 5]
Floorplanning and placement, clock tree insertion & DFT insertion, routing, post</td></tr>
</table>

	PnRfunction & timing checks, interconnection architectures.
Text Books, and/or Reference Material	**Text Books:** 1. N. H. E. Weste and C. Harris, "*Principles of CMOS VLSI Design: A System Perspective*", 3rd Edition, Pearson Education 2007. 2. Jan M. Rabaey, AnanthaChandrakasan, BorivojeNikolic, "*Digital Integrated Circuits: A Design Perspective*", Second Edition, Pearson Education, 2016. **Reference Books:** 1. Michael L. Bushnell, Vishwani D. Agrawal, "*Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits*", Kluwer Academic Publishers 2002. 2. Sung-Mo Kang, Yusuf Leblebici, "*CMOS Digital Integrated Circuits*", 3rd edition, Tata McGraw-Hill, 2003.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	3	3	2	1	2	1	1	1	1	1	1	3	3	2
CO#2	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO#3	3	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	3	3	2	3	1	1	1	1	1	1	1	1	3	2	2
CO#6	3	2	2	2	1	2	1	1	1	1	1	1	3	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE719	Telecommunication Networks	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Analog Communication (ECC401), Digital Communication (ECC501)		CT+MT+EA					
Course Outcomes	CO#1: Learn about various types of networks appropriate for pre specified applications and operational scenarios. CO#2: Explain the information flow through various subsystems of a network. CO#3: Understand the current technology trends and business potential of future telecommunication networking paradigms.						
Topics Covered	Elements of telecommunication network. (2L) Computer networks. (8L) Landline telephone networks. (8L) Cellular mobile networks. (8L) Optical networks. (8L) Satellite networks. (8L)						

Text Books, and/or reference material	**Text Book:** 1. Communication Networks – J. Walrand. **Reference Books:** 1. Telecommunication Switching and Networks - P. Gnanasivam. 2. Optical and Wireless Communications – M. N.O. Sadiku.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	2	1	2	1	2	1	1	1	1	1	1	3	3	1
CO#2	3	2	3	1	1	1	1	1	1	1	1	1	3	3	1
CO#3	1	1	2	3	1	3	3	2	1	2	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Lecture (L)	Lecture (L)	Lecture (L)	
ECE720	Advanced Semiconductor Devices	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Physics of Semiconductor Devices (PHC331)		CT+MT+EA					
Course Outcomes	• **CO1**Understand state of the art in semiconductor device physics and electronic properties of semiconductor devices • **CO2** Acquire in depthknowledge of advanced field effect transistors and its applications • **CO3** Develop understanding about basic working principles of quantum well devices and heterojunction device simulations						
Topics Covered	**Module I: (L – 10)** Electronic properties and technologies of semiconductor Devices : SiGe and Group III-V compound semiconductors; Advanced Heterojunction bipolar Transistor (HBT) Devices: SiGe, GaAs, InP, GaN **Module II: (L – 10)** Advanced Field Effect Devices: Heterostructure Field Effect Transistors (HFETs), Modulation Doped Field Effect Transistors (MODFETs), High Electron Mobility Transistors (HEMTs) **Module III: (L – 4)** Resonant Tunneling Devices (RTDs); Single Electron Transistors (SETs) **Module IV: (L –10)** Strained layer superlattices and quantum well devices; RF & digital applications; Noise Characteristics **Module V: (L –8)** HBT Modelling; Heterojunction device simulation						
Text Books,	1. Theory of Modern Electronic Semiconductor Devices, Kevin F. Brennan, April S. Brown, 2002 John Wiley & Sons, Inc.						

and/or reference material	2. Physics of Semiconductor Devices, S.M. Sze, Wiley, 1981 3. GaAs High-Speed Devices: Physics, Technology, and Circuit Applications, C.Y. Chang, F. Kai, Wiley, 1994 4. Device Electronics for Integrated Circuits, R. S. Muller & T. I. Kamins, Wiley, 2003 5. Silicon VLSI technology: fundamentals, practice and modelling, J. D. Plummer, M. D. Deal, P. B. Griffin, Pearson Education, 2009

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	-	-	-	-	-	-	-	2	3	2	2
CO#2	2	2	3	2	3	-	1	-	-	-	1	3	2	2	3
CO#3	2	2	3	2	1	-	-	-	-	-	-	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE721	Random Process	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT),End Assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Characterize probability models and function of random variables. • CO2: Evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits. • CO3: Recognize, interpret and apply a variety of deterministic and nondeterministic random processes that occur in engineering. • CO4: Calculate the autocorrelation and spectral density of a random process and recognize the relation beteen them.						
Topics Covered	7. Introduction: Basic of Probability theory, Bernoulli's Trials (5L) 8. Random Variables: PDF, PMF, Function of one random variable,Mean, Variance, Moments, Characteristics functions of random variables (10L) 9. Two random variables, Joint density and distribution function, Two functions of two random variables (8L) 10. Stationary random processes, Autocorrelation function, Cross correlation function, Covariance, PSD (7L) 11. Linear systems with random inputs (3L) 12. Markov Processes, Markov chain, CTMC, DTMC (4L) 13. Poisson process, Poissson distribution, Gaussian process (5L)						

Text Books, and/or reference material	**Text Books**: 5. A. Popoulis, U. Pillai, *Probability, random variables and stochastic processes*, Tata McGraw-Hill Inc., 4th Ed., New Delhi, 2017 6. P. Peebles, *Probability, random variables and random signal priniciples*, McGraw-Hill Inc., 4th Ed., New York, USA, 2001 7. C. W. Therrien, M. Tummala, *Probabilty and random processes for electrical and computer engineers*, 2nd Ed., CRC press, printed in India, 2012 **Reference Books**: 3. George R. Cooper, C. D. McGillem, *Probabilistic methods of signal analysis and system analysis*, Oxford University Press, 3rd Ed. , New Delhi, 2007 4. Alberto Leon-Garcia, *Probability and random processes for electrical engineering*, Pearson Education Inc., 2nd Ed., 2007

COURSE ARTICULATION MATRIX

Mapping the Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	2	2	1	1	1	-	1	1	2	3	3	1	2
CO#2	3	2	2	2	2	-	-	-	-	1	1	1	3	2	2
CO#3	3	2	2	3	2	-	-	-	-	-	-	1	3	2	1
CO#4	3	2	3	3	2	-	-	-	-	-	-	1	3	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 46				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE722	Microwave Circuits and Techniques	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
Microwave Engineering (ECC502)		CT+MT+EA					
Course Outcomes	• **CO#1** Students will be able to learn the intricacies of design constraints at high frequency. • **CO#2**The students can design and synthesize planar circuits and can provide reasoning for the obtained results. • **CO#3** The basic training for understanding planar passive and active circuit design at microwave frequencies for defense and space applications would be enriched.						
Topics Covered	**Introduction: RF & Microwave Spectrum, Typical applications of RF and Microwave, Safety considerations**. [L-2] **Review of Transmission line theory. Concept of Scattering Matrix; Smith Chart** [L-2] **Microwave Waveguide and Waveguide Resonator** [L-6] Rectangular Waveguide- Design consideration, TE & TM modes, TE10 mode analysis, cut-off frequency, propagation constant, intrinsic wave impedance, phase and group velocity, power transmission,attenuation, waveguide excitation, wall current; Introduction of circular waveguide; Rectangular waveguide resonator- Design						

	consideration, resonant frequency, Q-factor, excitation. **Planar Transmission Line** [L-4] Propagation characteristics, Comparison for different characteristics of the above mentioned lines. Micro-strip lines, Coplanar waveguide, Slot line-design consideration, field patterns. **High frequency Circuit Elements** [L-6] Difference in High frequency and relatively low frequency behaviour of Lumped circuit components. Miniaturization and Design of Lumped components at High RF. Realization of reactive elements as Waveguide and Planar Circuit components. **Planar Passive Components and their S-matrix Representation** [L-8] N-port networks-Properties of S matrix, Transmission matrix & their relationships; Microwave passive components and their S matrix representation: Attenuators, Phase shifter, Power dividers, couplers, impedance matching elements as well as filters. **Semiconductor Microwave Devices and Circuits** [L-6] TED (Gunn diode) & Avalanche Transit Time (IMPATT) device, Schottky diode, PIN & applications; Microwave bipolar transistor, Microwave field effect transistor (MESFET). **Microwave Amplifier Design** [L-6] Basic consideration in the design of RF amplifier- Transistor S-parameter, Stability, matching network, noise figure; Matching network design using lumped elements and L-Section. Design of LNA. **Microwave Circuit Measurement** [L-6] VSWR meter, Tunable detector, Slotted line and Probe detector, Frequency meter, Network analyzer, Measurement of VSWR – low, medium and high, Measurement of power: low, medium and high, Frequency measurement.
Text Books, and/or reference material	**Text Books**: [1] High Frequency integrated Circuits, SorinVoinigescu, Cambridge University Press, New Delhi 2013 [2] Microwave Engineering D M Pozar, John Wiley and Sons, New Delhi **Reference Books** [1] Microwave Integrated circuit, K. C. Gupta. [2] Microwave Devices & Circuits 3/e, Samuel Y. Liao. [3] Microstrip lines and Slot lines, K.C. Gupta, R. Garg. , I. Bahl, P. Bhartia, Artech House, Boston, 1996. [4] Microwave Integrated Circuits, By Ivan Kneppo, J. Fabian, P. Bezousek

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO# 2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO# 11	PO #12	PSO# 1	PSO# 2	PSO# 3
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit	
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours		
ECE723	Semiconductor Device Modeling	PEL	3	0	0	3	3	
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))						
Physics of Semiconductor Devices (PHC331), Electronic Devices and Circuits I (ECC302)		CT+MT+EA						
Course Outcomes	**CO 1:** To describe the essential properties of semiconductor materials **CO 2:** To analyse the carrier concentration as a function of temperature, doping and illumination conditions **CO 3:**To understand the transport of charge carriers for the operation of semiconductor devices. **CO 4:**To derive the physical model of P-N junctions. **CO 5:** To analyze the charge, electric field, potential and current distributions in the MOS devices **CO 6:**To develop the fundamental understanding of device modeling							
Topics Covered	**Module 1** **[6L]** Semiconductor Fundamentals: Equilibrium carrier concentrations (electron statistics, density of states, Effective Mass, Bandgap), Drift Velocity, Mobility and Scattering, Drift & Diffusion Current, Continuity equation. **Module 2** **[8L]** Metal-Semiconductor and PN Junction: Metal-Semiconductor junctions, Current-Voltage Characteristics, Surface Effect, Ideal static pnjuntionI-V characteristics, Diode Equation, Breakdown, Junction Capacitances **Module 3** **[6L]** MOS Capacitor: Modes of operation (accumulation, depletion, strong/weak inversion), Capacitance versus voltage (High ad Low Frequency), Flat Band Voltage, Nonideal effects (poly depletion, surface charges), **Module 4** **[6L]** Long Channel MOSFET Devices: Review of operation. Threshold Voltage Model, I-V Model **Module5** **[8L]** Short Channel MOSFET Devices: Scaling effects (short channel, narrow channel effects, drain induced barrier lowering), Channel velocity limitations (saturation velocity, interface scattering, mobility models). Subthreshold current, Hot carrier effects (impact ionization, gate/substrate currents, threshold voltage degradation, velocity overshoot, ballistic							

	effects) **Module 6** **[5L]** Advanced Devices: SOI, SiGe, strained Si, Alternative oxide/gate materials, Alternative geometries (raised source/drain, dual gate, vertical, FinFET), Tunnel FETs, Memory Devices (DRAM, Flash) **Module 7:** **[3L]** Introduction to BSIM Model: BSIM family of Compact device models, BSIM6 model
Text Books, and/or reference material	1. B. G. Streetman and S. Banerjee, Solid State Electronic Devices, 2. S. M. Sze, Physics of Semiconductor Devices 3. S. M. Sze, Semiconductor Devices: Physics and Technology 4. Michael Shur, Physics of Semiconductor Devices, 5. NanditaDasGupta and AmitavaDasGupta, Semiconductor Devices, 6. C. T. Sah, Fundamentals of Solid State Electronics

COURSE ARTICULATION MATRIX

Mapping CO (Course outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO# 1	PSO #2	PSO #3
CO#1	2	1	1	1	1	1	1	1	1	1	1	2	3	2	1
CO#2	2	2	1	1	1	1	1	1	1	2	1	2	3	2	2
CO#3	2	3	2	2	2	1	1	1	1	2	1	2	3	2	2
CO#4	3	3	3	2	1	1	1	1	1	2	1	2	3	3	2
CO#5	3	3	3	3	3	1	1	1	1	2	1	3	3	3	3
CO#6	3	3	3	2	3	2	1	1	2	2	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE724	Biomedical Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO 1**: Understand concept of Biomedical Instrumentation • **CO 2**: Understand basic building blocks of Biomedical Instruments • **CO 3**: Apply quantitative analysis techniques to Biomedical Instruments • **CO 4**: Learn design techniques of Biomedical Instruments • **CO 5**: Investigate application specific Biomedical Instruments						
Topics Covered	**Module I: Introduction to Biomedical Measurements and Instrumentation [L-1]** **Module II: Static and dynamic characteristics of Biomedical Instruments [L-7]** Static characteristics of elements, Dynamic characteristics of elements, Quasi- static characteristics of elements, Static characteristics of systems, Dynamic characteristics of						

	systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth **Module III: Error and Noise in Biomedical Measurements [L-4]** Sources of noise in measurement systems, mathematical modelling of noise, environmental effects, Effects of Interfering and Modifying inputs, Error analysis, Systematic error, Random error. Statistical methods for noise and error analysis and Modelling. **Module IV: Reliability analysis of Biomedical Instruments [L-4]** Concept of Reliability, Reliability of measurement systems, Reliability enhancement strategies **Module V: Operation of Physiological organs, Bioelectric Potentials and Electrodes [L-7]** Operation of Physiological organs, Operation of Nerves system, Operation of heart, Operation of lungs, Operation of Muscular system, Sources of bioelectric potentials, Bioelectric electrodes **Module VI: Building blocks of Biomedical Instruments [L-9]** Bioelectric sensors, Sensors, Signal conditioning circuits, Bridge circuits, Amplifiers, Filters, Oscillators, ADC, Signal Processing Units, Microcontrollers, Data Presentation elements **Module VII: Application Specific Biomedical Instruments [L-10]** Clinical thermometer, Sphygmomanometer, Digital Statoscope, ECG signal measuring instrument, EEG signal measuring instrument, Medical Imaging techniques, Assistive Respiratory system
Text Books, and/or reference material	**Text Books:** 1. John G. Webster, *Medical Instrumentation Application and Design*, 4ed, Wiley, 2015 2. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 3. R.S. Khandpur, *Handbook of Biomedical Instrumentation*, 3rd Edition, McGraw Hill Education;, 2014 **Reference Material:** 1. Research Articles

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome)
to
PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	-	-	-	-	2	-	-	-	-	-	-	3	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO#3	1	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO#4	2	1	2	-	-	2	-	-	-	-	-	-	3	2	-
CO#5	1	1	1	3	-	2	-	-	-	-	-	-	2	1	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE725</td><td>Ad Hoc & Sensor Networks</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT) and End Assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">●CO1 To understand the fundamentals of Wireless Adhoc and Sensor networks and its application

●CO2To study the various protocols at various layers and its differences with traditional protocols.

● CO3 Understanding Communication Theoretic aspects of Adhoc / Sensor Networks

●CO4 To learn about the issues and challenges in the design of wireless ad hocand Sensor Networks.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Fundamentals of wireless communication technology, Radio propagation, characteristics of wireless channels, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet. (4L)
2. Introduction to Adhoc/Sensor networks: Key definitions of adhoc/ sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, driving applications, issues in adhoc wireless networks, issues in design of sensor network, sensor network architecture, data dissemination and gathering. (6L)
3.Communiation Theoretic Framework for Multihop Adhoc Networks: Topology, Route Discovery , Average no of Hops, Bit Error Rate of Multihop Route, Connectivity, Life Time, Network behaviour (8L)

4. MAC Protocols : MAC protocols for adhoc/sensor wireless networks, design goals, classification of MAC protocols, Schedule-Based and Random Access-Based Protocols, Sensor-MAC, Zebra-MAC MAC protocols for sensor network, Hybrid-TDMA/FDMA, CSMA based MAC, S-MAC, LEACH, IEEE 802.15.4. location discovery, quality, other issues, (10L)
5.Routing Protocols: Issues in designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power aware routing protocols. (8L)

6.QoS and Energy Management : Issues and Challenges in providing QoS, classifications, MAC and network layer solutions, QoS frameworks, energy management. (6L)</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education - 2008. 2. Ozan K.Tonguz and Gianluigi Ferrari, " Ad Hoc Wireless Networks" Wiley India **Reference Books:** 3. Feng Zhao and LeonidesGuibas, "Wireless sensor networks ", Elsevier publication - 2004. 4. Ian F. Akyildiz, Mehmet Can Vuran "Wireless Sensor Networks", Wiley 5. Chiara Buratti, Marco Martalò, Gianluigi Ferrari, Roberto Verdone, " Sensor Networks with IEEE 802.15.4 Systems, Distributed Processing, MAC and Connectivity

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	2	2	1	1	1	1	1	1	1	3	2	3
CO#2	3	3	3	2	1	1	1	1	1	1	1	1	3	2	2
CO#3	3	3	3	2	1	1	2	1	1	1	1	1	3	2	2
CO#4	3	3	3	2	1	1	2	1	1	1	1	1	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EIGHTH SEMESTER

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE810	Wireless Communication	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	On successful completion of this course, students should have the skills and knowledge to : **CO1**. Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints. **CO2**. Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium. **CO3**. Analyze and design receiver and transmitter diversity techniques.Determine the appropriate transceiver design of multi-antenna systems and evaluate the data rate performance. **CO4**. Application of Fundamental Digital Communication Concepts in Fading Channel. **CO5**. Understanding suitable Modulation Schemes and Multiple access forWireless Communication. **CO6**. Describe and differentiate four generations of wireless standard for cellular networks.Understand wireless communication systems with key 3G (e.g., CDMA) and 4G (OFDM) technologies.
Topics Covered/ Syllabus	1. Introduction to Wireless Personal Communication, Mobile radio systems.**(02 hrs)** 2. Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, Call blocking, Erlang B, Cell splitting and Directional antenna etc**(06 hrs)** 3. Characterization of wireless radio channel, propagation path models. Fading and Shadowing, Statistical Characterization of fading Channel **(08 hrs)** 4. Receiver Techniques for fading Channel: Detection of Signal in Fading Channel, Diversity Techniques, Time and Frequency Diversity, Receive Diversity(SC, MRC, EGC, Switch & Stay), BER and outage with Diversity, Equalization, Fading mitigation **(10 hrs)** 5. Modulation schemes for wireless Communication (MSK, GMSK), OFDM **(07hrs)** 6. Multiple access techniques: TDMA, FDMA, spread spectrum techniques, Cellular CDMA, Wide-band CDMA, Multiple access Performance of CDMA, Capacities of multiple access schemes, comparison. **(06 hrs)** 7. Wireless Networks and Standards: GSM, CDMA cellular standard, 3G, 4G**(03 hrs)**
Text Books, and/or Reference material	**Text Books**: 1.Wireless Communications: Principles and Practice: Theodore Rappaport, Pearson, 2nd Edition. 2.Wireless Communication: Andrea Goldsmith, Cambridge University Press.
	Reference Books/Materials: 1. Principles of Modern Wireless Communication Systems Theory and Practice: Aditya K Jagannatham, McGraw-Hill India. 2. Fundamentals of Wireless Communication: David TSE and PramodViswanathan, Cambridge University Press

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	2	2	1	1	2	1	1	1	1	1	1	3	2	2
CO#2	3	3	3	2	1	2	1	1	1	1	1	1	2	2	2
CO#3	3	3	3	2	1	2	2	1	1	1	1	1	3	3	2
CO#4	3	3	3	2	1	2	1	1	1	1	1	1	3	3	2
CO#5	3	3	3	2	1	2	1	1	1	1	1	1	3	2	3
CO#6	3	3	3	2	2	2	1	1	1	1	1	1	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics & Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE811	Mixed Signal IC Design	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))				
Analog IC Design (ECE712) Digital IC Design (ECE622)			Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination				

Course Outcomes

After the completion of the course, the student will be able to:

- **CO1:** Explain the operation of various High performance OTAs/Opamps.
- **CO2:** Design Analog Circuits using gm/ID techniques.
- **CO3:** Create the Layout of a CMOS Mixed Signal System.
- **CO4:** Analyze a Comparator.
- **CO5:** Interpret the use of Switched Capacitor Circuits in Sampled data Systems
- **CO6:** Compare Data converter architectures based on Area/Power/Speed.

Topics Covered

Module I. Introduction [L – 9]

Overview of Mixed-Signal Design flow. Design of high performance Fully Differential Opamps: Telescopic cascode, Folded cascode, two-stage, Rail-to-Rail, Gain boosted OTAs/Opamps, Comparison.

Module II. g_m over I_D Design Process [L – 4]

g_m over I_D technique: Transconductor efficiency in subthreshold, moderate and strong inversions. Various design plots: g_m/I_D, g_m/g_{ds}, f_T etc., and their use in Analog Design. Design of a CS Amplifier, and Two stage Opamp using g_m/I_D technique.

Module III. Opamp performance Metrics:[L – 2]

Slew rate & Settling time, CMRR, PSRR, Linearity, Distortion, Offset Cancellation techniques.

Module IV. Layout Techniques[L – 3]

Layout Techniques: Introduction to CMOS process, CMOS Layers, Design rule basics, DRC, LVS, Passive and Transistor layout, Fingering, Interdigitization. Matching components: Common centroid, Use of Dummy. Matching error, error propagation.

	Module V. Switched Capacitor Circuits [L – 5] Basic philosophy of Switched capacitor circuits, design of switched-capacitor amplifiers and integrators, effect of opamp finite gain, bandwidth and offset, circuit techniques for reducing effects of opamp imperfections, switches and charge injection and clock feed-through effects. **Module VI. Sample and Hold[L – 4]** Operation of sample and holds circuits and theirs non-idealities. Comparators: Opamp based, Strong Arm Regenerative Latch, Latch dynamics, Offset reduction. **Module VII. Data Converters [L – 12]** Fundamentals of data converters; Introduction to data converter metrics: SNR, DNL, INL, Offset & Gain Error, SINAD, ENOB, SFDR, SDNR, Settling time etc. Nyquist rate D/A converters - voltage, current and charge mode converters, hybrid and segmented converters. Nyquist rate A/D converters (Flash, interpolating, folding flash, SAR and pipelined architectures) **Module VIII. Phase Locked Loop [L – 3]** Basic PLL topology, dynamics of simple PLL, Multiplier, phase detectors, lock acquisition, Phase frequency detector, Loop filters, Charge Pump PLLs.
Text Books, and/or Reference materials	**Text Books:** 1. BehzadRazavi, "*Design of Analog CMOS Integrated Circuits*", McGraw Hill, 2nd Ed. 2017 2. Tony Chan Carusone; David Johns; Kenneth Martin, "*Analog Integrated Circuit Design*", Wiley, 2nd Ed. 2013, 3. BehzadRazavi, "*Principles of Data Conversion System Design*", Wiley-IEEE Press, 1994 4. Adel Sedra , Kenneth SmithTony Chan Carusone, Vincent Gaudet, "*Microelectronic Circuits*", Oxford ; 8th Ed.; 2020 **Reference Books/Materials:** 1. R.Gregorian, "*Introduction to CMOS Opamps and comparators*", Wiley, 1999 2. Rudy J. Van De Plassche, "*CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters*", Springer, 2nd Ed. 2003. 3. Ali Hajimiri, Caltech, "*New Analog Circuit Design*",https://www.youtube.com/watch?v=403CnTftB4M&list=PLc7Gz02Znph-c2-ssFpRrzYwbzplXfXUT

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	3	3	1	1	1	1	1	1	1	1	1	3	3	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	1	2	1	2	2	1	1	1	1	1	2	3	2
CO#6	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE812</td><td>Broadband Communication</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="2">Analog Communication (ECC401),
Digital Communication (ECC501)</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand the evolution, current state and tendency of broadband communication networks.
CO2: Learn the technologies and protocols behind broadband communication networks.
CO3: Learn the existing access technologies.
CO4: Acquire the capacity of solving problems related to the design, configuration and deployment of broadband communication networks.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Course Introduction– [4L]
Components of Broadband Communication Systems; Communications Network Architecture; Cable Broadband Data Network Architecture; Importance of Broadband Network Architectures; Future of Broadband Telecommunications; Internetworking.
Internet based Networks – [6L]
Internet Protocol Suite; IPv6 standard; Voice over IP; Internet Security; Flow Control; Intranet and Extranet Technologies and Applications; Intranet and Extranet Design Issues.
Networking Technologies– [8L]
X.25 and Frame Relay; Fiber Channel Technology and Topologies; Synchronous Optical Network (SONET), Synchronous Digital Hierarchy (SDH), Next-Generation SONET (NGS); Virtual Private Network-Types, General Architecture, Advantages and Disadvantages, Security Issues; ISDN and BISDN, ATM Networks and Applications.
Access Networks– [8L]
Digital Subscriber Line (DSL) Systems- Asymmetric Digital Subscriber Lines (ADSL), Symmetric Digital Subscriber Lines (SDSL), High Data Rate Digital Subscriber Lines (HDSL), Very High Data Rate Digital Subscriber Lines (VDSL); Cable Modem Systems- Technology, External and Internal Modems; Passive Optical Networks (PON)- Types, Advantages and Disadvantages of TDM PONs, Security Issues; Broadband over powerline.
Wireless Networks – [8L]
Wireless LAN; Wireless ATM; Cellular Communications; WiMAX; Satellite Communication-Types, Orbital and Propagation Characteristics, VSAT Networks, Satellite Radio, Satellite based Internet.
Network Management and Security– [8L]
Simple Network Management Protocol (SNMP); Management Information Base (MIB); Remote Network Monitoring (RMON); Network Threats and Security Requirements; Cryptography; Firewalls; Intrusion Detection; Security Standards- IPSec, DES.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Cajetan M Akujuobi, Matthew N O Sadiku, “Introduction to Broadband Communication Systems”, Boca Raton, Fla. Chapman & Hall/CRC Raleigh, NC SciTech.
2. Lorne G Mason, Augusto Casaca, “Broadband Communications”, IFIP Advances in Information and Communication Technology, Springer.
Reference Book:Preston C Russett, James W Chesebro, David T McMahan, “Internet Communication”, series by Digital Formations.</td></tr>
</table>

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	1	1	2	1	1	1	1	2	1	2	3	2	1
CO#2	2	2	2	2	2	1	2	1	1	3	1	2	3	2	2
CO#3	2	2	2	2	2	1	2	1	1	3	1	2	3	2	2
CO#4	2	2	2	2	3	2	3	2	1	2	2	3	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE813</td><td>Digital Image Processing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="2">Signals and Systems (ECC 303),
Digital Circuits and Systems (ECC402),
Digital Signal Processing (ECC603)</td><td colspan="6">The assessment methods consist of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">• CO1: Understand image enhancement and restoration techniques.
• CO2: Analyze digital images through multiresolution techniques.
• CO3: Understand the application of morphological processing and segmentation in digital images.
• CO4: Ability to interpret digital image recognition techniques.</td></tr>
<tr><td colspan="2" rowspan="4">Topics Covered mapped to Course Outcomes</td><td colspan="4">Topic Details</td><td>(No. of classes)</td><td>Course Outcomes (COs)</td></tr>
<tr><td colspan="4">Digital Image Fundamentals: Image acquisition, Sampling, Quantization, Resolution, Relationship between pixels, Geometric transforms, Convolution and Correlation.</td><td>4</td><td>CO#1</td></tr>
<tr><td colspan="4">Image Enhancement: Gray level intensity transforms, Histogram processing, Image sharpening and smoothening operations (spatial and frequency based).</td><td>6</td><td>CO#1</td></tr>
<tr><td colspan="4">Image Restoration: Model of image degradation, Noise models, Restoration in the presence of noise only spatial filtering, Periodic noise reduction by frequency domain filtering, Estimating the degradation function, Weiner filtering, Constrained least squares filtering, Image interpolation and resampling.</td><td>6

6</td><td>CO#1

CO#2,CO#</td></tr>
</table>

	Multi-resolution Image Processing: Short time Fourier transform, Wavelet function, Wavelet series, Discrete wavelet transform and multi-resolution analysis, Image decomposition and compression using discrete wavelet transform. **Compression and Encoding of Image**: Redundancy, Entropy coding, Lossy compression, Lossless compression, Quality preserving adaptive compression. **Morphological Processing**: Dilation and erosion, Opening and closing, Hit or Miss transform, Algorithms for feature extraction. **Image Segmentation**: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, Segmentation by morphological watersheds, Use of motion in segmentation. **Patterns in Images and their Applications**: Basics of features, Principal component analysis, Decision tree and feature hierarchy, Scale invariant feature transform, Histogram of oriented gradient.	5 5 6 4	4 CO#1, CO#4 CO#3, CO#4 CO#3, CO#4 CO#4
Text Books, and / or reference material	**Text Books**: 1. Digital Image Processing: R C Gonzalez and R E Woods; Pearson Education. 2. Guide to Signals and Patterns in Image Processing- Foundations, Methods and Applications: Apurba Das; Springer. 3. Digital Image Processing and Computer Vision: Sonka, Hlavac and Boyle; Cengage Learning (India Edition). **Reference Books**: 1. Digital Image Processing: K R Castleman; Pearson Education. 2. Digital Image Processing: S Sridhar; Oxford Higher Education.		

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) & Programme Specific Outcome (PSO)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO #2**	**PSO #3**
CO#1	3	3	3	3	3	-	-	-	2	-	1	-	3	3	1
CO#2	3	3	3	3	3	-	-	-	2	-	1	-	3	3	1
CO#3	2	3	3	3	2	-	-	-	1	-	1	-	3	3	1
CO#4	2	2	3	3	3	-	-	-	2	-	1	-	3	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 46</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE814</td><td>Error Control Coding</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
</table>

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Digital Circuits and Systems (ECC402),Digital Communication (ECC501)	CT+MT+EA

Course Outcomes	**CO1:Acquire** idea about different types of error control coding techniques. **CO2:Understand** generator matrix, encoding and decoding of different codes. **CO3:Learn** LDPC, BCH, RS and Turbo codes. **CO4:Analyze** and mitigate errors in channels. **CO5:Differentiate** between different coding strategies.
Topics Covered	1. Introduction to Linear Algebra: Group, Ring, Field, Vector Space. [L-7]2. Binary Linear Block Codes : Generator and Parity Check Matrices, Dual Codes, Decoding, General properties of linear block codes, Hamming Code. [L-9] 3.Cyclic Codes: Algebraic description, Encoding and Decoding of Cyclic codes. [L-7] 4. BCH Codes: Properties, Encoding and Decoding. Examples [L-4] 5. Reed Solomon (RS) Codes: Definition, Decoding of RS codes. Examples [L-4] 6. Convolution Codes: Definition, Encoding Trellis and State representation, Viterbi decoding, Error probability. [L-8] 7. LDPC Codes : Definition, Construction, Regular and irregular LDPC, Belief Propagation, Tanner Graph, Decoding, Iterative Decoding. [L-4] 8.Turbo Codes: Definition, Construction methods, Decoding; Polar codes. [L-3]
Text Books, and/or reference material	**Text Books**: 1.Shu Lin and Daniel.J.Costello Jr. ,*Error Control Coding; Fundamentals and applications:* 2nd Ed., Pearson India, New Delhi, 2010. 2.J. C. Moreira and P. G. Farrel, *Essentials of Error Control Coding,* 1st Ed., Wiley India, 2006 **Reference Book**: Todd.K. Moon, *Error Correction Coding: Mathematical Methods and Algorithm,*1stEd.,Wiley India, New Delhi, 2005.

COURSE ARTICULATION MATRIX

PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	1	1	1	1	-	1	-	-	1	-	1	2	2	2
CO#2	2	2	2	2	1	-	-	-	-	-	-	1	3	2	2
CO#3	2	2	1	2	1	-	1	-	-	1	-	1	2	3	2
CO#4	3	1	3	2	2	-	-	-	-	-	-	1	3	2	2
CO#5	1	1	2	1	1	-	-	-	-	-	-	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE815	Embedded System Design	PEL	3	0	0	0	3

Pre-requisites	Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA)):
Basic Electronics (ECC01), Introduction to Computing (CSC01), Digital Circuits and Systems (ECC402), Microprocessors and Microcontrollers (ECC503)	Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination

Course Outcomes	After the completion of the course the student will be able to • **CO 1:** Understand use of Microprocessor in Microcontrollers and Microcomputer • **CO 2:** Interface I/O devices with Microprocessor in Microcontrollers and Microcomputer • **CO 3:** Design software-controlled hardware systems • **CO 4:** Investigate application specific embedded systems
Topics Covered	**Module I: Intel 8051 Microcontroller[L-4]** Architecture of Intel 8051 Microcontroller using functional blocks, Crystal oscillators, Digital I/O Pins, Digital I/O ports, 8051 Microcontroller programmer, limitations of Intel 8051 Microcontroller. **Module II: ATmega Microcontrollers and Arduino[L-4]** Architecture of ATmega Microcontrollers using functional blocks, Hardware components of Arduino boards, ADC, Analog input pins, Digital I/O pins, PWM signals, PWM pins, Serial communication pins, Arduino shields, Limitations of ATmega Microcontrollers and Arduino. **Module III: Raspberry Pi Micro-Computer [L-4]** ARM processor, Hardware components of Raspberry Pi Micro-computer, GPIO pins in Raspberry Pi board, PWM signals, Raspberry Pi OS, In-built data communication devices, Limitations of Raspberry Pi Micro-Computer. **Module IV: I/O devices for Micro controllers and Microcomputers [L-5]** Sensors, Resistive sensors, Capacitive sensors, Inductive sensors, Actuators, Motors, Signal conditioning circuits, Amplifiers, Filters, Display elements, Data storage devices, Compatibility of several transducers with Intel 8051 Microcontroller, ATmega Microcontrollers and Arduino, Raspberry Pi Micro-Computer **Module V: Embedded System Programming using Keil [L-7]** Keil editor and compiler, Keil Programming for Intel 8051 Microcontroller, Program uploading to 8051 Microcontroller, I/O programming, Interfacing Analog and Digital sensors and actuators with Intel 8051 Microcontroller, Interrupt programming in 8051, Keypad and Display element interfacing with 8051. **Module VI: Embedded System Programming using Arduino language [L-7]** Arduino editor and compiler, Arduino Programming, Program uploading to Arduino board, I/O programming, Interfacing Analog and Digital sensors and actuators with Arduino, Serial communication and Data transmission in Arduino, Interrupt programming in Arduino, Keypad and Display element interfacing with Arduino. **Module VII: Embedded System Programming using Python[L-7]** Raspberry Pi OS, Python programming, Interfacing Analog and Digital sensors and

	actuators with Raspberry Pi, I/O programming in Raspberry Pi, Serial communication and Data transmission in Raspberry Pi, Interrupt programming, Keypad and Display element interfacing with Raspberry Pi. **Module VIII: Case studies [L-4]** Application specific embedded system design using 8051 Microcontroller, Arduino, Raspberry Pi, Password lock device using Embedded system, Smart home using embedded system, Motor controller using Embedded system
Text Books, and/or reference material	**Text Books:** 1. T. Givargis, F. Vahid , *Embedded System Design: A Unified Hardware / Software Introduction*, Wiley; Student edition, 2006 2. E. A. Lee, S. A. Seshia, *Introduction to Embedded Systems - a Cyber Physical Systems Approach*, PHI Learning Pvt Ltd, MIT Press; Second edition, 2019 3. M. A. Mazidi, *The 8051 Microcontroller and Embedded Systems: Using Assembly and C*, Pearson Education India; 2nd edition, 2007 **Reference books:** 1. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 2. T. W. Schultz, *C and the 8051, Vol.I: Hardware, Modular Programming & Multitasking*, Prentice Hall; 2nd edition, 1997 3. S. Monk, *Programming Arduino: Getting Started with Sketches*, Second Edition, McGraw-Hill, 2nd edition, 2016 4. J. Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, Newnes; 3rd edition, 2013 5. S. Monk, *Raspberry Pi Cookbook: Software and Hardware Problems and Solutions,*Shroff/O'Reilly; Second edition, 2016 6. D. Molloy, *Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux*, Wiley; 1st edition, 2016 7. Research Articles

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	3	-	-	-	-	2	-	-	-	-	-	-	3	-	-
CO#2	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO#3	1	3	-	1	-	-	-	-	-	-	-	-	3	2	-
CO#4	1	1	-	3	-	2	-	-	-	-	-	-	3	1	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 50				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE816	RF and MMIC	PEL	3	0	0	3	3
Pre requisite			Course Assessment methods: (Continuous Assessment				

<table>
<tr><td colspan="2"></td><td>(CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="2">Electromagnetic Theory and Transmission Lines (ECC403),
Electronic Devices and Circuits I and II (ECC302, ECC504),
Microwave Engineering (ECC502)</td><td>Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">● CO1:Grasp the in-depth account of GaAs, InP and SiGe, technologies and able to describe all the key techniques for the design
● CO2: Understand circuit design issues at RF and microwave frequencies for integrated circuit design for transceiver
● CO3: Assimilate the characterization of RF and microwave monolithic integrated circuits</td></tr>
<tr><td>Topics Covered</td><td colspan="2">Introduction to RFIC and MMIC: [L – 6]
Introduction to microwave integrated circuit (MIC), RF , microwave, mm wave and sub mm wave spectrum, history, applications and technology of MMICs Advantages and disadvantages of MMIC; enhancement of device technology that have contributed to RGIC and MMIC; Transceiver architectures, concept of IIP, nonlinearities, dynamic range and system noise
Review of Transmission line theory. Concept of Scattering Matrix[L – 4]
N-port networks-Properties of S matrix, Transmission matrix and their relationships
Microwave and mm wave Waveguide and Resonators [L – 4]
Rectangular Waveguide- design consideration, TE and TM modes, TE_{10} mode analysis, cut-off frequency, propagation constant, intrinsic wave impedance, phase and group velocity, power transmission, attenuation, waveguide excitation, wall current; Introduction of circular waveguide; Rectangular waveguide resonator design consideration, resonant frequency, Q-factor, excitation.
Planar Transmission lines and Resonators [L – 4]
Propagation characteristics, comparison for different characteristics of the above mentioned lines. strip line, micro-strip line, coplanar waveguide, Slot line-design consideration, Substrate integrated waveguide, non radiating dielectric guides, Design synthesis and analysis
Passive Components and their S-matrix Representation [L – 6]
Microwave and mm wave passive components and their S matrix representation: Attenuators, Phase shifter, Directional coupler, Bethe-hole coupler, magic tee, hybrid ring, circulators, Isolators; design of planar power dividers and couplers; design procedure of filter using insertion loss method-specification, low-pass prototype design, scaling and conversion, implementation.
Devices for RFIC and MMIC [L – 4]
CMOS, SOICMOS, GaAs, GaN and SiGe transistor technology
Amplifier Design [L – 6]
Basic consideration in the design of microwave amplifier- transistor S-parameter, Stability, matching network, noise figure; matching network design using lumped elements and L-Section. Five major MMIC amplifier topologies: the reactively matched amplifier, the lossy match amplifier, the feedback amplifier, the distributed amplifier and various forms of actively matched amplifier; design of low noise and high power amplifiers
Oscillator , Mixer, Switches, Attenuator and Phase Shifter [L – 8]CAD techniques for large-signal oscillator design; phase noise; MMIC VCO design; and MMIC injection-locked oscillator design, analysis of mixer circuits; diode mixers; coupling structures; active FET mixers; resistive FET mixers; image-rejection mixers; single-sideband mixers; sub-harmonically pumped mixers; and distributed FET mixers.GaAs FET switch mechanism and the development of an equivalent circuit for switching operation; different schemes for the</td></tr>
</table>

	realization of GaAs MMIC variable attenuators; MMIC phase shifters, implemented under either analogue or digital control. **Integrated Antenna:[L-4]**monolithic integrated antennas; integrated antenna selection; substrate choice; measurement issues; packaging; photonic bandgap antennas; micromachined antennas, including trench and cavity etching; and microelectromechanical systems antennas **Microwave and mm wave measurement basics [L – 4]** VSWR meter, tunable detector, slotted line and probe detector, spectrum analyzer, network analyzer, measurement of VSWR – low, medium and high, measurement of power: low, medium and high, frequency measurement.
Text Books, and/or reference material	**Text Books:** 1. I D Robertson; S Lucyszyn, *RFIC and MMIC design and technology*, IET circuits, devices and systems series, 13 2. SorinVoinigescu,*High Frequency Integrated Circuits*, Cambridge UniveityPress,UK, 2013G 3. R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi. 4. David. M. Pozar, *Microwave Engineering*, 2/e, 1998 (John Wiley & Sons). 5. H Bryant, *Principles of microwave Measurement*, London : P. Peregrinus Ltd. on behalf of the Institution of Electrical Engineers, c1988 **Reference Books:** 1. P A Rizzi, *Microwave Engineering: Passive Circuits*, 2000, PHI 2. R E Collin, *Foundations of Microwave Engineering*, John Wiley and Sons India Pvt. Ltd.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	2	3	1	1	2	1	1	2	2	2	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics & Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE817	Design with Op-Amp & Analog Int. Circuits	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods: (Continuous Assessment (CA), Mid-term Assessment (MA) and End-term Assessment (EA))				

Electronic Devices and Circuits I and II (ECC302, ECC504)	CA comprises of : Assignment(s), Quiz(zes) /Class test(s)
Course Outcomes	After the completion of the course the student will be able to • **CO1:**Define various parameters/terms associated with Operational Amplifier. • **CO2:**Describe the internal structure of an Opamp using functional blocks • **CO3:**Design Adder/Subtractor/Integrator/Differentiator using Opamps • **CO4:**Define Slew rate and estimate settling time. • **CO5:**Explain the operation of a DAC. • **CO6:**Analyze the operation of an ADC.
Topics Covered	**Module I. Introduction to Operational Amplifier [L – 7]** Basic Op-amp characteristics, DC characteristics, Unity Gain Frequency, CMRR, PSRR, offset voltages and currents, Input and output impedances, Slew rate and Frequency limitations. Ideal opamp circuit analysis. Amplifiers: inverting/non-inverting, Summing amplifiers, and Difference amplifiers. Integrator and differentiator. Understanding negative feedback, concept of virtual short. **Module II. OpAmp Circuits [L – 6]** Current to Voltage and Voltage to Current converters, Current Amplifiers, Difference Amplifiers, Instrumentation Amplifiers. Log/Antilog Amplifiers, Transducer bridge Amplifiers. **Module III. Active Filters [L – 7]** Filter classification and transfer functions, First order active filters, Audio filter applications, Second order filter responses, KRC filters, State variable and bi-quad filters. Sensitivity. Filter approximations, Cascaded design **Module IV. Non liner Circuits using OpAmp [L – 6]** Voltage comparators and applications, Schmitt Trigger, Precision rectifiers, Peak detectors, Sample and Hold amplifiers. Mutivibrators, Triangular wave generators, V to F and F to V converters **Module V. Voltage references and Regulators [L – 6]** General performance considerations, Voltage references, Linear regulators and Switching regulators Voltage mode control and current mode control. **Module VI. Data Converters [L – 7]** Performance specifications, Digital to Analog Conversion techniques, Multiplying digital to analog converter applications. Analog to Digital Conversion techniques, Flash, SAR, Dual-slope ADC operation. **Module VII. Phase Locked Loop[L – 3]** Basic operation of PLL, Block diagram, performance parameters, applications.
Text Books, and/or Reference materials	**Text Book:** 1. Sergio Franco, "*Design with Operational Amplifiers and Analog Integrated Circuits*", McGraw-Hill, 2017. **Reference Book:** 1. Ramakant A Gayakwad, "*Op-Amps and Linear Integrated Circuits*", Pearson, 4th Edition 2015.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	2	3	1	1	1	1	1	1	1	1	1	2	3	2

CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	1	3	1	2	1	2	2	1	1	1	1	1	2	2	2
CO#6	3	2	2	2	1	1	1	1	1	1	1	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 46				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE818	Satellite Communication	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT) and End Assessment (EA))					
Electromagnetic Theory and Transmission Lines (ECC403), Microwave Engineering (ECC502),Analog and Digital Communication(ECC401, ECC501),Antennas and Wave Propagation (ECC601)		Assignments, Mid Semester and End Semester Examination					
Course Outcomes	CO#1 To compute the satellite orbit parameters, design orbits and be able to classify them based on Kepler's six elements. CO#2 Understand the concept of satellite launching and positioning of satellites in orbits CO#3 Can do computations of link design and classify different losses in propagation for space communication. CO#4 Assimilate the concept of multiple accessing techniques in satellite communication. CO#5 Develop ability to classify different types of application of satellite communication.						

Topics Covered	**Introduction** Basic concepts, Frequency allocation for satellite services, orbital & spacecraft problems, comparison of networks and services, modulation techniques used for satellite communication. Spectrum Management**[L-4]** **Orbits** Two body problems, orbital mechanics, geostationary orbit, change in longitude, orbital manoeuvres, orbital transfer, and orbital perturbations. Launch Vehicles- principles of Rocket propulsion, powered flight, Lauch vehicles for communication satellite **[L-10]** **Satellite subsystems and satellite link design** Altitude and orbit control (AOC) Subsystem, TT&C, power system, spacecraft antenna, transponder, Friis transmission equation, G/T ratio of earth station.**[L-8]** **RF link-** noise, the basic RF link, satellite links (up and down) , optimization RF link, inter satellite link, noise temperature, Antenna temperature, overall system temperature, propagation factors, rain attenuation model. Tropospheric and Ionospheric effect.**[L-8]** **Multiple access** FDMA, TDMA, CDMA techniques, comparison of multiple access techniques, error connecting codes.**[L-8]** **Application of satellite** in remote sensing and surveillance; Basic of remote sensing, Electromagnetic Radiation principles, Atmospheric window, Indian satellite sensing satellite system, Active, Passive, ground based and space based remote sensing. **[L-8]**
Text Books, and/or reference material	**Text Books**: [1] Dennis Roddy, Satellite Communication, 4/e, McGraw Hill [2] Pratt and Bostian, Satellite Communication, 2/e, John Wiley and Sons. [3] Louis J. Ippolito, Jr.Satellite Communications Systems Engineering: Atmospheric Effects, Satellite LinkDesign and System Performance,Second Edition, John Wiley. **Reference Books**: [4] Recommendation ITU-R P.618-11, P Series Radio Wave Propagation. [5] Floyd F. Sabins, Remote Sensing: Principles and Interpretation, 3rd edition (August 1996), W H Freeman & Co. [6] Tri T Ha, Digital Satellite Communication, McGraw Hill

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO# 10**	**PO #11**	**PO# 12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2
CO#4	1	2	2	1	1	2	2	1	2	1	1	1	3	3	2
CO#5	2	3	1	2	1	1	1	2	2	1	1	1	2	1	2

Correlation levels 1, 2 or 3 as defined below:

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<table>
<tr><td colspan="9">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 46</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE819</td><td>RFIC Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Analog and Digital Communication (ECC401, ECC501),
Signals and Systems (ECC303),
Analog IC Design (ECE712)</td><td colspan="6">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After going through the course, student will be able to
• CO1: Analyze various architectures of today's digital radio transmitters and receivers.
• CO2: Analyze and design basic RF building-blocks in CMOS technology.
• CO3: Define basic RF measurements parameters such as S-parameters, sensitivity, noise figure, IIP3
• CO4: Assimilate the design techniques VCO, LNA as well as other front-end circuits</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Module-I: Introduction to RF IC Design Concepts [L – 6]
Basic Concepts in RF Design, passive on chip components and layouts, transceiver architectures, circuit analysis techniques at radio frequencies.
Module-II: Semiconductor radio frequency components [L – 8]
RF diodes, MOS transistor, determination of model parameters, parasitics of MOS transistors and high frequency behaviour of basic amplifier.RF Transistor Materials – The Transistor Equivalent Circuit – Y Parameters – S Parameters – Understanding RF Transistor Data Sheets; BSIM3 parameters of NMOS and PMOS transistors, matching and biasing networks for transistors
Module-III: Noise and non-linearity. [L – 4]
Noise Figure and representation of non-linearity, intermodulation products and intercept points
Module-IV: Filter Design [L – 4]
Resonator and filter configurations, realization of filter for specific transfer function, implementation of filters a coupled line filter.
Module V:RF Transistor Amplifier[L – 8]
Stability consideration, constant, gain and noise figure circles. Low Noise Amplifiers: SNR, LNA topologies, power constrained CMOS LNA design, low-current CMOS inverter LNAs, low-voltage LNA topologies, differential LNA design methodology, process variation in tuned LNAs, impact of temperature variation in tuned LNAs, low-noise bias networks for LNAs, MOSFET layout of LNA.
Module-VI: RF Mixers [L – 6]
Basic design concepts, single end diode mixer single balanced and double balanced diode mixer design. Transistor mixers, , conversion loss.
Module-VII: RF Oscillators [L – 6]
Basic Principles, Phase Noise, negative resistance oscillators, transistor oscillators, VCO design methodology, frequency scaling of CMOS VCO, VCO layoutPhase lock loops, frequency synthesizers
Module-VIII:RF power amplifiers [L – 4]
Class A, AB, B, C, D, E and F amplifiers, modulation of power amplifiers, linearity considerations</td></tr>
</table>

Text Books, and/or Reference material	**Text Books:** 1. R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi. 2. SorinVoinigescu,*High Frequency Integrated Circuits*, Cambridge UniveityPress,UK, 2013. **Reference Books:** 1. BehzadRazavi, RF Microelectronics Prentice Hall of India, 2001 2. Thomas H. Lee, The Design of CMOS Radio Frequency Integrated Circuits, Cambridge University Press.

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO# 10	PO #11	PO #12	PSO# 1	PSO# 2	PSO# 3
CO#1	2	1	2	1	2	2	1	1	1	1	1	1	2	1	1
CO#2	3	2	2	2	2	2	1	1	1	2	1	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1	3	3	2
CO#4	1	2	2	1	1	2	2	1	2	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE820</td><td>Low Power Circuits and Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))</td></tr>
<tr><td colspan="2">Electronic Devices and Circuits I (ECC302), VLSI Design (ECC602)</td><td colspan="6">Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO 1: Learn to design and optimize CMOS logic circuits and extract parasitic elements.
CO 2: Understand sources of power dissipation and be able to estimate energy dissipation in typical circuits
CO 3: Apply different techniques to minimize dynamic dissipation.
CO 4: Learn the different sources of leakage in MOS transistors and how to minimize leakage dissipation at the device level as well as in circuit design.</td></tr>
<tr><td colspan="2">Syllabus/ Topics Covered</td><td colspan="6">Module-I:(L – 05)
Introduction: Need for Low power VLSI chips, MOS Transistor structure and device model, The CMOS inverter and other gates; why CMOS for Low Power? CMOS Logic design methodology, Circuit optimization for performance.
Module – II: (L – 06)</td></tr>
</table>

	CMOS layout and Fabrication: Typical CMOS circuit layout, IC fabrication overview, CMOS process flow, Imperfections in fabrication steps, Design rules and their importance; MOS device details – parasitic elements and their estimation, importance of device scaling. **Module – III:** (L- 06) **Power dissipation mechanisms in CMOS circuits**: Static and Dynamic dissipation, Dynamic power dissipation – switching loss, short circuit dissipation, concept of switching activity; Concept of signal activity, signal probability and activity, Signal activity computation – Boolean difference, estimation of probability and activity in complex logic circuits; **Module – IV**: (L – 08) **Dynamic dissipation management** –Supply voltage scaling approaches**:** Static Voltage Scaling; Single-level Voltage Scaling (SVS), Speed vs dissipation, Speed management approaches, circuit level – Transistor sizing, Architecture level – Parallel and pipeline architectures, Algorithm level transformations; Static Voltage Scaling Design Procedure, Critical path and its management; Multi-level Voltage Scaling (MVS), MVS issues – Layout, Level converters, Power up/down sequencing; Dynamic Voltage Scaling; Dynamic Voltage and Frequency Scaling (DVFS), DVFS architecture. **Module-V:** (L – 06) **Dynamic dissipation management – Switched capacitance minimization approaches**: What is switched capacitor? Switched capacitor minimization techniques – Hardware/Software trade-off, Bus Encoding, Use of Number system, Glitching Power minimization, Architecture Level Optimization, Clock gating, State Encoding of FSM's. **Module-VI:** (L – 06) **MOS Transistor revisited**: Review of quantum theory of solids, concept of quantum mechanical tunneling, Leakage mechanisms in MOS transistor – diode leakage, sub-threshold current, sub-threshold swing; short channel effects – Gate tunneling, reducing gate tunneling – high-k technology, DIBL and GIDL effects; Recent advances in MOS transistor design – SOI technology, FinFET, Gate All Around (GAA) FET. **Module-VII:** (L – 03) **Static Power Optimization Techniques**: Comparison of static and dynamic loss in modern chips; Stand-by and Run-time leakage; Stand-by leakage reduction techniques, Transistor stacking, VT CMOS approach, Power gating, MT CMOS technology, Power gating issues, DVFS with Power gating; Run-time leakage reduction, Dynamic V_{DD} scaling, Dual V_t approach, V_t hopping. **Module-VIII:** (L – 02) **Battery operated system design**: Battery construction and working principle, Battery capacity and energy density, comparison of different storage cell technologies; Battery charging and discharging profiles and their effects on battery capacity and life; Design of multi-battery system installations.
Text Books, and/or reference material	**Text Books:** 1. Ajit Pal,**"***Low Power VLSI Circuits and Systems***"**, Springer, 2015. 2. Kaushik Roy and Sharat C Prasad, **"***Low Power CMOS VLSI circuit Design***"**, John Wiley and Sons, 2000. **Reference Books:** 1. Anantha P Chandrakasan and Robert W Brodersen, **"***Low Power Digital CMOS Design***"**, Kluwer Academic Publishers, Holland, 1995. 2. Gary B Yeap K, **"***Practical Low Power Digital VLSI Design***"**, Kluwer Academic Publishers, 1998. 3. Kuo J B and Lou J H, **"***Low Voltage CMOS VLSI Circuits***"**, John Wiley and Sons, Singapore, 1999.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	3	2	2	1	1	1	1	1	1	2	2	2	1
CO#2	2	3	2	1	1	1	1	1	1	1	2	1	2	2	1
CO#3	3	3	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#4	3	2	3	2	1	1	1	1	1	1	1	1	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective(PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE821	Advanced Antenna Synthesis	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Electromagnetic Theory and Transmission Lines (ECC403), Analog Communication (ECC401), Digital Communication (ECC501), Antenna and Wave Propagation (ECC601)		CT+MT+EA					
Course Outcomes	• **CO 1:** Ability to characterize resonance and radiation property of an antenna based on application • **CO 2:** Learn various design parameters that affects an antenna and antenna array patterns. • **CO 3:** Understand different types of antenna based on the radiation mechanism like wire antenna, aperture antennas, traveling wave antenna. • **CO 4:** Understand different types of antenna based on the design mechanism like log periodic antenna, log spiral antenna and electrically long antenna as well as electrically small antenna. • **CO 5:** Analyze and synthesize different types of antennas for different wireless communications.						
Topics Covered	**Module I. Brief review on antenna fundamentals [L – 4]** Antenna fundamentals; Vector potentials and solution of the vector potential wave equation; Antenna theorems and definitions. **Module II. Antenna Array design and characterization [L – 6]** Linear, planar and circular array - theorems and pattern synthesis. **Module III. Integral Equations[L – 4]** Moment method, self and mutual impedances **Module IV. Scanning antennas [L – 8]** Signal processing antennas, travelling wave and broadband antenna; Concept of smart						

	antennas. **Module V. Microstrip antennas [L – 8]** Operating principle, modes, field patterns, impedance, feeding techniques and polarization; Arrays and feed networks. **Module VI.** Aperture antennas **[L – 6]** Huygen's principle, Babinet's principle; Fourier transform theory and its applications; The Geometrical theory of diffraction and uniform theory of diffraction techniques and their applications. **Module VII. Antenna measurements[L – 6]** Antenna ranges, Impedance Measurements, Radiation Patterns, Gain Measurements, Directivity Measurements, Radiation Efficiency, Current Measurements, Polarization Measurements.
Text Books, and/or reference material	**Text Books:** [1] C. A. Balanis, *Antenna Theory : Analysis and Design*, 3rd ed., John Wiley & Sons, Hoboken, New Jersey, 2005 [2] John D.Kraus, Ronald J.Marhefka "*Antennas: for all Applications*" 4th ed.,, Tata McGraw- Hill Inc., New Delhi, 2006. **Reference Books:** [1] E C Jordan and K G Balmain, *Electromagnetic Waves & Radiating Systems*, 2nd ed., Pearson, New Delhi, 2015 [2] R. C. Johnson and H. Jasik, "*Antenna Engineering handbook*", 3rd ed., Mc-Graw Hill Inc., New York, 1993. [3] I. J. Bhal and P. Bhartia, "Micro-strip antennas", Artech house, Dedgham, MA, 1980. **Online Reference Material(s):** https://nptel.ac.in/courses/117107035/

COURSE ARTICULATION MATRIX

Mapping CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12	PSO #1	PSO #2	PSO #3
CO#1	2	1	2	1	1	2	1	1	1	-	-	2	2	2	1
CO#2	3	2	2	1	1	2	1	1	1	-	-	1	2	1	1
CO#3	3	3	1	1	1	-	-	-	-	-	-	1	3	1	1
CO#4	1	2	1	1	1	3	2	1	1	-	1	1	3	1	2
CO#5	2	3	2	2	1	1	1	1	1	-	1	2	2	3	2

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<table>
<tr><td colspan="8">Department of Electronics & Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE822</td><td>DSP Architectures in VLSI</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods:
(Continuous Assessment (CA), Mid-term assessment (MA) and End term assessment (EA))</td></tr>
<tr><td colspan="3">VLSI Design (ECC602),
Digital Signal Processing (ECC603)</td><td colspan="5">CA comprises of : Assignment(s), Quiz(zes) /Class test(s)</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course, the student will be able to:
• CO 1: State VLSI design methodology for signal processing systems.
• CO 2: Describe VLSI algorithms and architectures for DSP.
• CO 3: Implement/Simulate basic architectures for DSP using Matlab/CAD tools.
• CO 4: Analyze DSP architectures and evaluate their performance.
• CO 5: Discuss various issues that need to be addressed when implementing DSP algorithms in real hardware with finite resources such as processing speed, memory, and bit resolution.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I. Introduction to Digital Signal Processing [L – 6]
Review of DSPfundamentals: Discrete Systems: Representation of Systems, Properties of DSP systems, Difference equation and its relationship with system function, Impulse response and frequency response.
Module II. Digital Signal Processing Algorithms [L – 6]
Introduction for DSP algorithms: VLSI Design flow, Mapping algorithms into Architectures: Graphical representation of DSP algorithms – signal flow graph (SFG), data flow graph (DFG), critical path, dependence graph (DG). Data path synthesis, control structures, Optimization at Logic Level and architectural Design, Loop bound and iteration bound, Algorithms for computing iteration bound
Module III. Introduction to DSP systems [L – 5]
DSP Systems, Parallel and pipeline of signal processing application: Architecture for real-time systems, latency and throughput related issues, clocking strategy, power-aware structures, array architectures; Pipelining processing of Digital filter, Parallel processing, Parallel and pipelining for Low power design, Optimization with reference to speed, area and power, asynchronous and low power system design, ASIC (application-specific integrated circuits) and ASISP (application-specific instruction-set processors) design.
Module IV. Systolic Array Architecture [L – 6]
Methodology of systolic array architecture, FIR based Systolic Array, Selectionof Scheduling Vector, Matrix multiplication of systolic array.
Module V. Signal processing Architectures [L – 7]
Convolution technique, Retiming concept, Folding/Unfolding Transformation, Fast convolution, Cook-Toom algorithm, modified Cook-Toom algorithm. CORDIC architecture.
Module VI. Scaling and Round-off noise [L – 5]
Scaling and round-off noise, scaling operation, round-off noise, state variable description of digital filters, scaling and round-off noise computation, round-off noise in pipelined IIR filters.
Module VII. Low Power Design [L – 7]
Theoretical background, Scaling v/s power consumption, power analysis, Power estimation approach, Power reduction techniques.</td></tr>
</table>

Text Books, and/or Reference materials	**Text Book:** Keshab K. Parhi, "*VLSI Digital Signal Processing Systems, Design and Implementation*", Wiley-Interscience, 1999. **Reference Book:** 1. Uwe Meyer-Baese, "*Digital Signal Processing with Field Programmable Gate Arrays*", Springer, Third Edition, 2007. **NPTEL/SWAYAM/Other Video Lectures:** 1. Prof. N. Chandrachoodan, IITM, (2019) *Mapping Signal Processing Architectures in VLSI*

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO# 1**	**PSO# 2**	**PSO# 3**
CO#1	2	1	3	3	1	1	1	1	1	1	1	2	2	2	1
CO#2	3	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO#3	3	2	3	1	1	1	1	1	1	1	1	1	3	2	2
CO#4	1	2	3	2	1	1	1	1	1	1	1	1	3	3	2
CO#5	2	3	2	2	1	2	2	1	1	1	1	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE823	Internet of Things Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous (CT), Mid-Term (MT),End Assessment (EA)					
NIL		CT+MT+EA					
Course Outcomes	**CO1**: Explain the term IoT and understand the main components of IoT systems. **CO2**: Recognize, interpret and apply a variety of enabling technologies, connectivity technologies and communication protocols that occur in IoT systems. **CO3**: Design and analysis of a complete working IoT system involving prototyping, programming and data analytics						
Topics Covered	14. **Introduction to IoT**: Introduction and definition of IoT; -Basics of networking: Network types; Network topologies; OSI model; Adressing TCP/IP; -Predecessors of IoT: WSN; M2M; Cyber Physical Systems **(5L)** 15. **IoT enabling technologies**: Cloud computing; Big data analytics; Embedded systems; -IoT levels: level 1 to level 6 -Introduction to sensors; actuators; microcontrollers, and their interfacing: Sensors-characteristics, types; Sensor interfacing-interfacing gas sensors with nodeMCU/ Arduino, interfacing pH sensor, interfacing pulse sensor. -Actuators: types, functions						

	-Microcontrollers and overview **(8L)** **16. IoT communication technologies:** -Constrained nodes and networks: types; lossy and low power networks -Protocols for messaging and transport: Messaging protocols- MQTT; CoAp; XMPP; DDS -Protocols for addressing and identification: IPV4; IPV6; Uniform Resource Identifier (URI); 6LoWPAN; Discovery protocols like universal plug and play; multicast DNS. **(6L)** 17. **IoT connectivity technologies:** IEEE 802.15.4; Zigbee; RFID; NFC; Sigfox; LoRa; NB-IoT; WiFi; Bluetooth **(2L)** 18. **Cloud for IoT**: challenges; selection of cloud service provider; introduction to Fog computing- working principle; edge and Fog computing; security aspects. **(2L)** 19. **Data analytics**: Data analysis; Machine learning: supervised and unsupervised; Types of ML models: classification; regression; clustering; Model building process; modeling algorithm; model performance; Big data platform. **(5L)** 20. **IoT case studies and future trends**: Agricultural IoT; Vehicular IoT; Healthcare IoT; Evolution of new IoT paradigms- IoBT; IoV; IoNT; IoD; IoSpace; NFV; SDN; 5G as IoT enabler. **(6L)** 21. **IoT hands on:**-Home automation: smart lighting;Air pollution monitoring;Health care: elderly fall detection; Prevention of drowsiness of drivers by IoT based smart drivers assistance systems. **(9L)**
Text Books, and/or reference material	**Text Books**: 5. Shriram K Vasudevan; Abhishek S Nagarajan; RMD Sundaram, *Internet of Things*, 2nd Edition, Wiley, New Delhi, 2020. 6. S. Mishra, A. Mukherjee, A. Roy, *Introduction to IoT*, 1st Ed., Cambridge University, UK, 2021. **Reference Books**: 7. A. Bahga, V. Madisetti, *Internet of Things: A Hands-on approach,* 1st Ed., Universities Press (India) Pvt. Ltd., Hyderabad, 2014. 8. K. N. Raja Rao (editor), *Internet of Things: Concepts and Applications*, 1st ed., Wiley India, 2021.

COURSE ARTICULATION MATRIX

Mapping of Course Outcome (CO) to Programme Outcome (PO) and Programme Specific Outcome (PSO)															
PO/PSO CO	**PO#1**	**PO#2**	**PO#3**	**PO#4**	**PO#5**	**PO#6**	**PO#7**	**PO#8**	**PO#9**	**PO #10**	**PO #11**	**PO #12**	**PSO#1**	**PSO#2**	**PSO#3**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2	2	2	3
CO#2	3	2	2	2	2	1	1	-	-	1	1	2	3	2	3
CO#3	3	2	3	3	3	2	2	1	-	3	3	2	3	3	3

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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECE824</td><td>VLSI Testing and Verification</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA:15%), Mid-Term Assessment (MA:25%) and End-Term Assessment (EA:60%))</td></tr>
<tr><td colspan="3">Digital Circuits and Systems (ECC402), VLSI Design (ECC602)</td><td colspan="5">Continuous Assessment (CA): Quizzes/Class tests/Assignments/Attendance</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After successful completion of the course, the student will be able to:
• CO 1: Extend knowledge of the requirement of fault modeling in VLSI circuits.
• CO 2: Generate test vectors to test a circuit efficiently covering maximum faults.
• CO 3: Demonstrate the concept of Memory testing techniques.
• CO 4: Discuss Built-in-Self Test and its application in modern digital design.
• CO 5: Use modern tools for testing and verification.</td></tr>
<tr><td>Syllabus/
Topics Covered</td><td colspan="7">Module I. Introduction [L –4]
Physical faults and their modeling. Fault equivalence and dominance; fault collapsing, Fault simulation: parallel, deductive and concurrent techniques; critical path tracing.
Module II. Test generation for combinational circuits[L – 4]
Boolean difference, D-algorithm, Podem, random, etc. Exhaustive, random, and weighted test pattern generation; aliasing and its effect on fault coverage.
Module III. PLA testing[L – 4]
Cross-point fault model, test generation, easily testable designs.
Module IV. Memory testing [L – 4]
Permanent, intermittent and pattern-sensitive faults; test generation.
Module V. Delay faults and hazards [L – 6]
Test pattern generation techniques, ATPG and its different types.
Module VI. Test pattern generation for sequential circuits[L – 6]
Ad-hoc and structures techniques scan path and LSSD, boundary-scan.
Module VII. Built-in Self-Test techniques[L – 6]
LBIST and MBIST. Verification: logic level (combinational and sequential circuits), RTL-level (data path and control path). Verification of embedded systems. Use of formal techniques: decision diagrams, logic-based approaches.
Module VIII. ASIC/IP Verification[L – 4]
Direct and random testing, Error detection, and correction codes.
Module IX. Post-Silicon Validation [L – 4]
Functional test patterns development and validating, test program and test software to enable functional and tress testing of features, validation with real use case applications: OS boot and stress testing, performance validation with industry-standard benchmarks, characterization of various electrical and thermal parameters as per device specification.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book:
1. M. L. Bushnell and V. D. Agrawal, “Essentials of Electronic Testing for</td></tr>
</table>

Digital, Memory and Mixed-Signal VLSI Circuits", Springer, 2nd edition, 2004.

Reference Books:

1. A. Krstic and K-T Cheng, "*Delay Fault Testing for VLSI Circuits*", Kluwer Academic Publishers, 3rd edition, 2003.
2. N. K. Jha and S. Gupta, "*Testing of Digital Systems*", Cambridge University Press, 2nd Edition, 2003.
3. M. Abramovici, M. A. Breuer and A. D. Friedman, "*Digital Systems Testing and Testable Design*", Wiley-IEEE Press, 3rd Edition, 1994.
4. P. K. Lala, "*Fault Tolerant and Fault Testable*", Prentice-Hall, 4th Edition, 1986.

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)															
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	2	2	2	1	1	2	1	1	1	1	1	1	3	2	2
CO#2	2	1	2	2	1	2	1	1	1	1	1	1	2	2	2
CO#3	2	1	2	2	1	2	2	1	1	1	1	1	3	3	2
CO#4	2	1	2	2	1	2	1	1	1	1	1	1	3	3	2
CO#5	2	1	2	2	1	2	1	1	1	1	1	1	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECE825	Statistical Signal Processing	PEL	3	0	0	3	3
Pre-requisites		Continuous Assessments : Class Assessment (CA), Mid-Sem (MA) and End-Sem Assessment (EA)					
Digital Signal Processing (ECC603), Probability Theory for Engineering Application (ECO541) / any other equivalent subject from SWAYAM, NPTEL, etc.		(CA-15) +(MA-25) + (EA-60)					
Course Outcomes	**CO1:** **Students are able to apply hypothesis testing to signal and detection problems.** **CO2:** **Students are able to evaluate detector performance.** **CO3:** **Students can decide and choose among MLE, MAP and MMSE estimators given a parameter estimation task.** **CO4:** **Students are able to apply and design least squares based adaptive filters for stochastic signals.**						
Topics Covered	**1. Introduction to statistical signal processing (1 hr.)** **2. Module-1 : Introduction to Random Processes (6 hrs.)** Review of probability and random variables, Linear algebra of random variables, Random						

	processes, Linear shift invariant systems with random inputs, White noise and spectral factorization theorem **3. Module-2 :Estimation Theory(8 hrs.)** Linear models of random signals, Estimation theory 1, Estimation theory 2 - MVUE and Cramer Rao lower bound, Cramer Rao lower bound 2, MVUE through sufficient statistics, MVUE through sufficient statistics 2 **4. Module-3 :Methods of Parameter Estimation (4 hrs.)** Method of moments and Maximum likelihood Estimation (MLE), Properties of maximum likelihood estimation, Bayesian estimation, bayesian estimation 2 **5. Module-4 :Wiener Filter (5 hrs.)** Optimal linear filters : Wiener filter, FIR Wiener filter, Noncausal IIR Wiener filter, Causal IIR Wiener filter **6. Module-5 :Linear Prediction of Signals (4 hrs.)** Linear prediction of signals 1, Linear prediction of signals 2, Linear prediction of signals 3 **7. Module-6 :Adaptive Filter (4 hrs.)** Adaptive filters 1, Adaptive filters 2, Adaptive filters 3, Adaptive filters 4 **8. Module-7 :Recursive Least Squares (RLS) Adaptive Filter (4 hrs.)** Recursive least squares (RLS) adaptive filter, Recursive least squares (RLS) adaptive filter-2 **9. Module-8 :Kalman Filter (4 hrs.)** Kalman filter-1, Vector Kalman filter **10. Module-9 : Introduction to Applications of SSP (2 hrs.)** Common applications of SSP in communications, medical diagnosis, radar signal processing/climate modelling, pattern recognition, speech and audio processing, image and video processing, and geophysical signal processing
Text Books, and/or Reference Materials	**Text Books**: 1. M. H. Hayes, "Statistical Digital Signal Processing and Modeling " , 2002, John Willey 2. S. M. Kay "Fundamentals of Statistical Signal Processing : Estimation Theory", 1993, Prentice Hall 3. D. G. Manolakis, V. K. Ingle, and S. M. Kogon, "Statistical and Adaptive Signal Processing" 2000, McGraw Hill

COURSE ARTICULATION MATRIX

Mapping of CO (Course Outcome) to PO (Programme Outcome) and PSO (Programme Specific Outcome)														
PO/PSO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**	**PSO #1**	**PSO #2**	**PSO #3**
CO#1	3	1	2	1	3	3	3	1	2	2	1	2	3	3	2
CO#2	3	3	1	2	3	1	3	1	3	2	1	2	3	2	3
CO#3	3	3	1	3	3	2	2	1	3	2	1	2	3	2	2
CO#4	3	3	2	3	3	2	2	1	3	2	1	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN ELECTRICAL ENGINEERRING

2018 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in ______ Senate # _______________ # Item no: _______

DEPARTMENT OF ELETRICAL ENGINEERING

Program Name: Bachelor of Technology in Electrical Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR ELETRICAL ENGINEERING-B.TECH.
L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week
C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	EEC301	Network Analysis and Synthesis	3	1	0	4.0	4
3	EEC302	Electrical and Electronics Measurements	3	1	0	4.0	4
4	ECC331	Analog Electronics	3	1	0	4.0	4
5	PHC332	Electromagnetic Field Theory	3	0	0	3.0	3
6	PHS382	Physics Laboratory	0	0	3	1.5	3
7	EES351	Electrical and Electronics Measurements Lab	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EEC401	Power Systems - I	3	1	0	4.0	4
2	EEC402	Electrical Machines - I	3	1	0	4.0	4
3	EEC403	Digital Electronics	3	1	0	4.0	4
4	MEC431	Fluid and Thermal Engineering	3	0	0	3.0	3
5	YYO44*	Open Elective - I	3	0	0	3.0	3
6	EES451	Network Analysis and Synthesis Laboratory	0	0	3	1.5	3
7	ECS481	Analog Electronics Laboratory	0	0	3	1.5	3
8	MES481	Fluid and Thermal Engineering Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EEC501	Electrical Machines - II	3	1	0	4.0	4
2	EEC502	Control Systems	3	1	0	4.0	4
3	EEC503	Power Systems - II	3	1	0	4.0	4
4	EEC504	Power Electronics	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	ECS581	Digital Electronics Laboratory	0	0	3	1.5	3
7	EES551	Control Systems Laboratory	0	0	3	1.5	3
8	EES552	Electrical Machines Laboratory - I	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	15	4	9	23.5	28

Semester - VI							
Sl.	Code	Subject	L	T	S	C	H
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	EEC601	Advanced Power Systems	3	1	0	4.0	4
3	EEC602	Microprocessor and Microcontroller	3	1	0	4.0	4
4	EEE610 --	Depth Elective - 1	3	0	0	3.0	3
5	EEE610 --	Depth Elective - 2	3	0	0	3.0	3
6	EES651	Electrical Machines - II Laboratory	0	0	3	1.5	3
7	EES652	Power Electronics Laboratory	0	0	3	1.5	3
8	EES653	Power System Laboratory	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	2	9	21.5	26
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	EEE710 --	Depth Elective - 3	3	0	0	3.0	3
3	EEE710 --	Depth Elective - 4	3	0	0	3.0	3
4	EEE710 --	Depth Elective - 5	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	EES751	Microprocessor and Microcontroller Laboratory	0	0	3	1.5	3
7	EES752	Advanced Power System Laboratory	0	0	3	1.5	3
8	EES753	Electrical machine Design Laboratory	0	0	3	1.5	3
9	EES754	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
10	EES755	Project - I	0	0	3	1.0	3
		TOTAL	15	0	14	21.5	29
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EEE810 --	Depth Elective - 6	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	EES851	Project - II	0	0	15	5.0	15
5	EES852	Project Seminar	0	0	0	1.0	0
6	EES853	Viva Voce	0	0	0	1.0	0
		TOTAL	9	0	15	16.0	24

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45.0	22.0	22.5	23.5	21.5	21.5	16.0	172.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF ELETRICAL ENGINEERING
EEE610	Numerical Analysis
EEE611	Instrumentation
EEE612	Modern Control Systems
EEE613	Special Electrical Machines
EEE614	Signals and Systems
EEE615	Advanced Power Electronics
EEE616	Soft Computing Theory and Applications

7th Semester

	DEPARTMENT OF ELETRICAL ENGINEERING
EEE710	Renewable Energy Systems
EEE711	Advanced Power Converters
EEE712	Generalized Theory of Electrical Machines
EEE713	Electrical Drives
EEE714	Power System Planning, Operation and Control
EEE715	Embedded Systems
EEE716	FACTS Device
EEE717	Generation & Utilization of Electrical Power
EEE718	Advanced Control Systems
EEE719	Microprocessor & Embedded Systems
EEE720	Digital Signal Processing
EEE721	Design of Flight Control Law
EEE722	Power system restructuring & deregulation

8th Semester

	DEPARTMENT OF ELETRICAL ENGINEERING
EEE810	Power System Transients & Power Quality
EEE811	Smart Grid
EEE812	Power system Reliability

DETAILED SYLLABUS

Semester - I								
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of function, limit, differentiation, and integration.	CT+MT+EA

Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Edition, Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	Engineering Physics	PCR	2	1	0	3	3

Pre-requisites:	Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]

Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)						

	v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>ESC01</td><td>Environmental Science</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the importance of environment and ecosystem.
• CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system.
• CO3: Understand the scientific basis of local and as well as global issues.
• CO4: Apply of knowledge to develop sustainable solution.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2]
Human population and the Environment. [1]
Social issues and the Environment. [1]
Constituents of our Environment & the Natural Resources: Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5]
Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4]
Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5]
Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5]
Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3]
Pollution: Pollutants and their role in air and water pollution. [2]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005
2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006.
3.Principles of Environmental Science and Engineering – P. V. Rao, PHI.
4. Environmental Science and Engineering – Meenakshi, Prentice Hall India.
5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005.
6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XES51</td><td>ENGINEERING GRAPHICS</td><td>PCR</td><td>1</td><td>0</td><td>3</td><td>4</td><td>2.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Ability of mental visualization of different objects
• CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects
• CO3: Able to read/interpret industrial drawing and to communicate with relevant people</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6]
Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9]
Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9]
Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6]
Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6]
Dimensional techniques; international and national standards (ISO and BIS). [3]
Freehand graphics. [3]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1)… Engineering Drawing and Graphics – K Venugopal
2)… Engineering Drawing – N D Bhat
3)… Practical Geometry and Engineering Graphics – W Abbott</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>HSS51</td><td>Professional Communication Lab</td><td>PCR</td><td>1</td><td>0</td><td>2</td><td>3</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Improvement in linguistic proficiency of the learners
• CO2: Improvement in communicative ability of the learners</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Professional Communication: Introduction (1)
2. Technical Writing: Basic Concepts (2)
3. Style in Technical Writing (3)
4. Technical Report (2)
5. Recommendation Report (2)
6. Progress Report (1)
7. Technical Proposal (3)
8. Business Letters (3)
9. Letters of Job Application (2)
10. Writing Scientific and Engineering Papers (3)
11. Effective Use of Graphic Aids (2)
12. Presentation Techniques (6)
13. Group Discussion (6)
14. Interview Techniques (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book:
1. English for Engineers –Sudharshana& Savitha (Cambridge UP)

Reference Books:
1. Technical Communication—Raman & Sharma (Oxford UP)
2. Effective Technical Communication—M A Rizvi (McGraw Hill Education)</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text Books, and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of weak ac by pH meter. ii. Experiments based on conductivity measurement: Determination of amount of HCl conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, $Fe(acac)_3$, c bis(glycinato)copper (II) monohydrate and their characterization by m. p. , FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron present i supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>WSS51</td><td>WORKSHOP PRACTICE</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Study and practice on machine tools and their operations
• CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
• CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
• CO4: Develop basic electrical engineering knowledge for house wiring practice</td></tr>
<tr><td>Topics Covered</td><td colspan="7">M/c shop & Carpentry shop -- 3X3= 9hrs.
• Introduction on machining process.
• Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
• Introduction to woods- Types, structure, disease and defect of wood.
• Introduction to wood working machines and tools.
• Making of dovetail joint and bridle joint.
Welding Shop & Sheet metal -- 3X3= 9hrs.
• Introduction to welding.Safety and precautions in welding.
• Formation of weld bead by SMAW on mild steel flat.
• Formation of weld bead by oxy-fuel welding on mild steel flat.
• Introduction to sheet Metal works.
• Tools and Machines used in sheet metal works.
• Concept of development, marking out of metal sheets.
• Cutting and joining of metal sheets.
• Safety precautions, General warning needed in the shop floor.
Black smithy & Foundry -- 3X3= 9hrs.
• Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
• Safety and precautions in blacksmithy.
• Making of bars of different cross-sections.
• Making of hexagonal headed bolts.
• Forge welding.
• Introduction to Foundry Technology.
• Preparation of sand mould using Solid/Split Pattern.
Fitting & Electrical shop -- 3X3= 9hrs.
• Introduction to hand metal cutting tools with specifications, nomenclature and their use.
• Marking tools, measuring tools and their use.
• Fitting of joints of mild steel flats.
• Introduction to electrical hazards and safety precaution.
• Wire jointing and soldering.
• PVC Conduit Wiring controlled by separate single way switches.
• PVC Cashing Capping Wiring for two-way switches.
• Conduit wiring for the connection of a Calling Bell with In& Out Indicators.
• Batten Wiring and Cleat Wiring.</td></tr>
</table>

	• Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))						
NIL	CT+EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana.						

	• Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch start & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm.

	• Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	**12**	**4**	**10**	**21.0**	**26**

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of set theory, differential equations, and probability.	CT+MT+EA

Course Outcomes	
	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.

Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4) **Laplace and Fourier Transforms:**Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Edition), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Edition (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Mathematical Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC01</td><td>INTRODUCTION TO COMPUTING</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of computer.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software’s (operating Systems) and application software’s, languages, number system, logic gates.
CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators.
CO3: Develop conditional and iterative statements to write C programs.
CO4: Exercise user defined functions to solve real time problems
CO5: Inscribe C programs that use Pointers to access arrays, strings and functions.
CO6: Exercise user defined data types including structures and unions to solve problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2]
Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1]
Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2]
Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1]
C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2]
Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8]
Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5]
Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5]
Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10]
Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Let us C by Kanetkar
2. C Programming by Gottfried
3. Introduction to Computing by Balaguruswamy
4. The C-programming language by Dennis Ritchie
Reference Books:
1. Computer fundamental and programming in C by P Dey and M. Ghosh
2. Computer fundamental and programming in C by Reema Thareja
3. programming with C by Schaum Series</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC01</td><td>Basic Electronics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">(10+2) level mathematics and physics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Knowledge of Semiconductor physics and devices.
• CO2: Have an in depth understanding of basic electronic circuit, construction, operation.
• CO3: Ability to make proper designs using these circuit elements for different applications.
• CO4: Learn to analyze the circuits and to find out relation between input and output.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Semiconductors
1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium
1.2. Definitions of insulator, conductor and semiconductor using band diagram
1.3. Crystalline structure of semiconductor
1.3.1. Covalent bond
1.3.2. Generation of holes and electrons
1.3.3. Effect of temperature on semiconductor
1.4 Intrinsic semiconductor
1.5 Doping and Extrinsic semiconductor
1.5.1 n-Type semiconductor and band diagram
1.5.2 p-Type semiconductor and band diagram
1.5.3 Mass-action law of semiconductor
1.6. Conductivity of semiconductor (including mathematical expression)
1.7 Carrier transport phenomenon. (03 hrs.)
2. Diodes
2.1. Construction
2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only)</td></tr>
</table>

	2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra**

	11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates.(01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad&Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

		Department of Electrical Engineering					
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	ELECTRICAL TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))					
NIL		CT+MT+ EA					

Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts. • CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's • CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts. • CO4: introduce the basic concept of single-phase transformer. • CO5: analyze the transient phenomena in electrical circuits with DC excitation.
Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Education India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody

	c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XXC01</td><td>The Constitution of India and Civic Norms</td><td>PCR</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6"></td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Historical background of the Making of Indian Constitution (1 Hour)
2. Preamble and the Philosophical Values of the Constitution (1 Hour)
3. Brief Overview of Salient Features of Indian Constitution (1 Hour)
4. Parts I & II: Territoriality and Citizenship (1 Hour)
5. Part III: Fundamental Rights (2 Hours)
6. Part IV: Directive Principles of State Policy (1 Hour)
7. Part IVA: Fundamental Duties (1 Hour)
8. Union Government: President, Prime Minister and Council of Ministers (2 Hours)
9. Parliament: Council of States and House of the People (1 Hour)
10. State Government: Governor, Chief Mister and Council of Ministers (1 Hour)
11. State Legislature: Legislative Assemblies and Legislative Councils (1 Hour)
12. Indian Judiciary: Supreme Court and High Courts (1 Hour)
13. Centre-State Relations (1 Hour)
14. Reservation Policy, Language Policy and Constitution Amendment (1 Hour)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Primary Readings:
1) P. M. Bakshi, The Constitution of India, 18th ed. (2022)
2) Durga Das Basu, Introduction to the Constitution of India, 25th ed. (2021)
3) J.C. Johari, Indian Government and Politics, Vol. II, (2012)
Secondary Readings:
Granville Austin, The Indian Constitution: Cornerstone of a Nation (1966; paperback ed. 1999); Granville Austin, Working a Democratic Constitution: The Indian Experience (1999; paperback ed. 2003).</td></tr>
</table>

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XES52</td><td>GRAPHICAL ANALYSIS USING CAD</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduction to graphical solution of mechanics problems
• CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system
• CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method
• CO4: Determination of centroid of plane figures by graphical method
• CO5: Exposure to AutoCAD software for computer aided graphical solution</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Graphical analysis of problems on statics. [14]
• Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]</td></tr>
</table>

Text Books, and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output signals.						
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.: 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.						
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td>ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: understand the principle of superposition.
• CO2: understand the principle of maximum power transfer
• CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp.
• CO4: understand the calibration of energy meter.
• CO5: understand open circuit and short circuit test of single-phase transformer.
• CO6: analyze RLC series and parallel circuits
• CO7: understand three phase connections.
• C08: understand determination of B-H curve</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
1. To verify Superposition and Thevenin’s Theorem.
2. To verify Norton and Maximum power transfer theorem
3. Characteristics of fluorescent and compact fluorescent lamp
4. Calibration on energy meter
5. To perform the open circuit and short circuit test on single phase transformer
6. To study the balanced three phase system for star and delta connected load
7. Characteristics of different types of Incandescent lamps
8. Study of Series and parallel R-L-C circuit
9. Determination of B-H Curve for magnetic material</td></tr>
<tr><td>Textbooks, and/or reference material</td><td colspan="7">Textbooks:
1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru (Author), J M Chuma (Author), H U Ezea (Author)
2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)#**	**Total Hours**	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release &						

Follow through.
- Field events marking.
- General Rules of Track & Field Events.

BASKETBALL
- Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw.
- Rebounding- Defensive rebound, Offensive rebound.
- Individual Defensive- Guarding the man without ball and with ball.
- Pivoting.
- Rules of Basketball.
- Basketball game.

VOLLEYBALL
- Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike.
- Block- Single block, Double block, Triple block, Group block.
- Field Defense- Dig pass, Double pass, Roll pass.
- Rules and their interpretation.

FOOTBALL
- Dribbling- Square pass, Parallel pass, Forward pass.
- Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading.
- Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe).
- Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc.
- Feinting- Body movement to misbalance the opponent and find space to go with ball.
- Rules of Football.

CRICKET
- Batting straight drive.
- Batting pull shot.
- Batting hook shot.
- Bowling good length, In swing.
- Bowling out swing, Leg break, Goggle.
- Fielding drill.
- Catching (Long & Slip).
- Wicket keeping technique.
- Rules & Regulation.

BADMINTON
- Net play- Tumbling net shot, Net Kill, and Net Lift.
- Smashing.
- Defensive high clear/Lob.
- Half court toss practice, Cross court toss drop practice, Full court Game practice.
- Player Positioning, Placements.
- Rules & Regulation.
- Doubles & Mixed doubles match practice.

TABLE TENNIS
- Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.
- Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.
- Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin.
- Service: Backhand/Forehand- Push service, Deep push service, Rally service.

	• Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

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Semester - III								
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	**MAC331**	**Mathematics - III**	**3**	**1**	**0**	**4.0**	**4**
2	**EEC301**	**Network Analysis and Synthesis**	**3**	**1**	**0**	**4.0**	**4**
3	**EEC302**	**Electrical and Electronics Measurements**	**3**	**1**	**0**	**4.0**	**4**
4	**ECC331**	**Analog Electronics**	**3**	**1**	**0**	**4.0**	**4**
5	**PHC332**	**Electromagnetic Field Theory**	**3**	**0**	**0**	**3.0**	**3**
6	**PHS382**	**Physics Laboratory**	**0**	**0**	**3**	**1.5**	**3**
7	**EES351**	**Electrical and Electronics Measurements Lab**	**0**	**0**	**3**	**1.5**	**3**
8	**XXS381**	**Co-curricular Activities - III (Optional)**	**0**	**0**	**0**	**0.0**	**0**
		TOTAL	**15**	**4**	**6**	**22.0**	**25**

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	MATHEMATICS-III	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of topics included in MAC01 & MAC02		CT+MT+EA					

Course Outcomes

- CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
- CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
- CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
- CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.

Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC331	CO1	3	3	3	2	2	1	2	-	-	-	-	2
	CO2	3	3	2	2	2	1	2	-	-	-	1	2
	CO3	3	3	2	2	3	-	1	-	-	1	-	2
	CO4	3	2	2	3	2	1	1	-	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC301</td><td>NETWORK ANALYSIS AND SYNTHESIS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MAC02(MATHEMATICS -II), EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">Upon successful completion of this course, students should be able to:
• CO1: Apply the knowledge of basic circuital law, Network Theorem and network topology concepts in the formulation and solution of different electric network problems.
• CO2: Apply the Laplace transform to linear circuits and systems and analyze the signal synthesis, steady-state responses and transient response of DC and AC circuits using classical and Laplace transform methods.
• CO3: Evaluate two-port network parameters, their inter-relationship, different connections, representation two port network as T, Πand lattice form and also apply two-port network analysis in the design and analysis of filter and attenuator networks.
• CO4: Demonstrate the concept of complex frequency and analyze the behavior of the circuit’s response in frequency domain, understand the significance of network functions, pole- zero plots, Bode plot etc.of one and two port networks.
• CO5: Synthesize one port network two port network function, analyze and design different filters.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Network Theorems for circuit analysis with both independent and dependent sources, Super node & super mesh analysis, Coupled Circuits: Ideal Transformer, Analysis of multi-winding coupled circuits, Analysis of single tuned and double tuned coupled circuits. (5)
Network Topology: Network graph, Tree, Incidence matrix - Fundamental cut-sets and fundamental loops - Tie set and cut set schedules. Formulation of equilibrium equation on loop basis and node basis, Formulation of equilibrium equation in matrix form - Duality, Construction of dual of a network. (6)
Time and Frequency response of circuits Voltage/current relations for R, L, C and their equations in time domain. Initial and final conditions, first and second order differential equations, steady state and transient response. Analysis of transient and steady state responses using Classical technique as well as by Laplace transforms. Steady state response to step, ramp, impulse and sinusoidal input functions. (12)
Two-Port parameters: Open circuit, short circuit, transmission and hybrid parameters, relationship between parameter sets, reciprocity and symmetry conditions, parallel connections, parallel connection of two port networks. Network equivalents - Analysis of T, n , ladder and lattice networks . (8)
Network Functions: poles and zeros Network functions for one port and two port networks, driving point and transfer functions, ladder network, general network, poles and zeros of network functions, restrictions on Pole and zero locations for driving point functions and Transfer functions, time domain behavior from pole and zero plot. Bode plot. (5)
Fundamentals of Network Synthesis: Causality and stability, Hurwitz polynomials, positive real functions, synthesis of one port networks with two kinds of elements. Properties and synthesis of L-C, R-C, R-L driving point impedances, synthesis of R-L-C functions. Properties</td></tr>
</table>

	of transfer functions, zeros of transmission, synthesis of Y21 and Z21 with a 1- Ohm termination, synthesis of constant - resistance networks. (12) Passive Filter as a Two Port Network - Characteristics of Ideal Filter - Low pass and High Pass Filter. Design of constant K, m derived and composite filters (6)
Textbooks, and/or reference material	Textbooks: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. 3. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	2	1	3	3	3	3
CO2	3	3	3	3	3	1	2	1	3	3	3	3
CO3	3	3	3	3	3	1	2	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	3	3	3	3
CO5	3	3	3	3	3	1	2	1	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC302	ELECTRICAL & ELECTRONIC MEASUREMENT	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To develop an idea about the measurement processes • CO2: To learn the operating principle of ammeter, voltmeter, wattmeter and energy meter • CO3: To gain knowledge about Potentiometer and various resistance measurement techniques • CO4: Introduction to AC Bridges & Instrument Transformers • CO5: Familiarization with CRO and introduction to Digital Instrumentation						
Topics Covered	Basics of Measurement: Significance of measurement, Direct & Indirect methods of measurement, Classification of instruments, Static and dynamic characteristics of measurement system, Various types of error in measurement system, Error analysis by conventional and statistical methods, uncertainty analysis. (6) Basic electrical Instruments: Various torques in electrical instruments, various types of damping in instruments, Principle of operation of Permanent Magnet Moving Coil (PMMC) instrument, use of shunt and multiplier to extend the range of PMMC						

	instruments, Temperature compensation of PMMC instruments, principle of operation of Moving Iron (MI) instruments, Linearization of scale of MI instrument, extension of range of moving coil and iron instrument, Measurement of 3-phase power and wattmeter errors. Principle of operation of single-phase energy meter, Creep in energy meter and its compensation, testing of energy meter, Phantom loading (14) Potentiometers: Basic principle of ordinary slide wire potentiometer, principle of operation of DC Crompton's Potentiometer, Measurement of voltage, current, resistance and power by potentiometer, calibration of voltmeter, ammeter and wattmeter by potentiometer, Drysdale polar potentiometer, Gall Tinsley Coordinate potentiometer (6) Measurement of Resistance: Measurement of medium resistance by Wheatstone bridge, measurement of low resistance by Kelvin Double Bridge, measurement of high resistance by direct deflection method, loss of charge method and Megger. (4) AC Bridges: Comparison of measurement methods with whetstone bridge, Measurement of inductance, capacitance and frequency by AC Bridges (8) Instrument Transformers: Disadvantages of using shunts and multipliers for very high current and voltage measurement, Use of Current transformer for measurement of current, construction of current transformer, current transformer errors, effect of sudden open circuit of current transformer, use of potential transformer for voltage measurement, construction of potential transformer, potential transformer errors. (6) Measurement of phase and frequency: Measurement of frequency by electrical resonance frequency meter and Weston frequency meter. Measurement of phase or power factor by dynamometer type instrument, moving iron power factor meters, measurement of phase difference by synchroscope. (4) Cathode Ray Oscilloscope: Construction and principle of operation, Measurement of current, phase difference and frequency by CRO, Sampling Oscilloscope, Theory of storage oscilloscope, Digital Storage Oscilloscope. (4) Digital Instruments: Advantages of digital instruments over their analog counterparts, Different types of digital voltmeters, digital multimeter, digital frequency meter. (4)
Textbooks, and/or reference material	<u>Suggested Textbooks:</u> 1. Electrical Measurements & Measuring Instruments by Golding &Widdis, Wheeler's Student Edition 2. Electronic Instrumentation by HS Kalsi, Tata McGraw- Hill. <u>Suggested Reference Books:</u> 1. A course in Electrical and Electronic Measurements and Instrumentation by A.K.Sawhney, Dhanpat Rai & Co.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	1	1	3	1	2	2
CO2	3	3	3	3	3	2	1	1	2	1	2	2
CO3	3	3	3	3	3	2	1	1	2	1	1	1
CO4	3	3	3	3	3	3	2	2	2	1	2	2
CO5	3	3	3	3	3	2	2	1	3	2	2	2

Correlation levels 1, 2 or 3 as defined below:

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC331</td><td>Analog Electronics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Physics (PHC01)
Electrical Technology (EEC01)
Basic Electronics (ECC01)</td><td colspan="6">CT+MT+EA</td></tr>
</table>

<table>
<tr><td>Course Outcomes</td><td>CO # 1. Understanding the fundamental knowledge of analog devices and circuits
CO # 2. Familiarizing with the design of complex electronic circuits with the help of these fundamentals.
CO # 3. Enriching historical developments with facts that led to IC technology.
CO # 4. Acquainting with the present-day design tools using which one can synthesize and analyze the complex design problems.
CO # 5. Implementing the devices and circuits as a basic building block of electrical communication and other areas and enhancing problem solving skills.</td></tr>
<tr><td>Topics Covered</td><td>Module 1: <u>Signals and Amplifiers</u> [3L + 1T]
Signals; frequency spectrum of signals; analog and digital signals; amplifiers; circuit models for amplifiers; frequency response of amplifiers.
Module 2: <u>Operational Amplifiers and its Applications</u> [4L + 2T]
Characteristics of Operational Amplifiers and learning how to apply basic op-amps to design sophisticated op-amp circuits, including summing amplifiers, instrumentation amplifiers, integrators, and differentiators.
Module 3: <u>Diodes and its Applications</u> [3L + 1T]
Characteristics of Junction Diodes and how to use diodes to analyze diode circuits operating in the various bias regions: forward, reverse and breakdown; application of diodes in voltage regulator and rectifier circuits.
Module 4: <u>MOS Field Effect Transistors</u> [4L + 2T]
The physical structure of the MOS transistor; how the voltage between two terminals of the transistor controls the current that flows through the third terminal, and the equations that describe these current voltage characteristics; analysis and design of circuits that incorporate MOS transistors, resistors, and dc sources.
Module 5: <u>Bipolar Junction Transistors</u> [3L + 1T]
The physical structure of the bipolar transistor; how the voltage between two terminals of the transistor controls the current that flows through the third terminal, and the equations that describe these current voltage characteristics; analysis and design of circuits that incorporate bipolar transistors, resistors, and dc sources.
Module 6:<u>Transistor Amplifiers</u> [5L + 2T]
The use of MOS or bipolar transistor to make an amplifier; obtaining linear amplification from fundamentally non-linear MOS and bipolar transistor; modelling linear operation of a transistor around a bias point by an equivalent circuit that can be used in the analysis and design of transistor amplifiers; three basic ways to connect MOS or bipolar transistor to construct amplifiers with different properties; practical circuits for MOS and bipolar transistor amplifiers that can be constructed using discrete components.
Module 7: <u>Differential and Multistage Amplifiers</u> [4L + 2T]
The essence of the operation of the MOS and bipolar transistor differential amplifiers which includes rejection of common mode noise or interference and amplify</td></tr>
</table>

	differential signals; structure, analysis, and design of amplifiers composed of two or more stages in cascade. **Module 8**: Feedback in Amplifiers [3L + 1T] The general structure and advantages of negative feedback in amplifier circuit design; appropriate feedback topology to employ with amplifiers of each of the four types (voltage, current, transconductance, and transresistance); intuitive and insightful approach for the analysis of practical feedback amplifier circuits; why and how negative feedback amplifiers become unstable or oscillatory and how to design the circuit to ensure stable operation. **Module 9**: Frequency Response [4L + 2T] Low frequency response of discrete circuit common source and common emitter amplifiers; internal capacitive effects and high frequency model of the MOSFET and the BJT; high frequency response of common source and common emitter amplifiers; useful tools for the analysis of high frequency response in amplifiers; high frequency response of common gate and cascode amplifiers; high frequency response of source and emitter followers; high frequency response of differential amplifiers; other wideband amplifier configurations. **Module 10**: Building Blocks of Integrated Circuit Amplifiers [4L + 1T] Integrated Circuit (IC) design philosophy; IC biasing current sources, current mirrors, and current steering circuits; the basic gain cell; cascode amplifier; current mirror circuits with improved performance; some practical transistor pairings. **Module 11**: Output stages and Power Amplifiers [3L + 1T] Classification of output stages; class A output stage; class B output stage; class AB output stage; biasing the class AB circuit; variations on the class AB configuration; CMOS class AB output stages; IC power amplifiers; class D power amplifiers; power transistors. **TOTAL number of classes = 40 Lectures and 16 Tutorials**
Text Books, and/or reference material	**Text Books:** 1. Microelectronic Circuits by A S Sedra and K C Smith, Oxford University Press. 2. Electronic Devices by Thomas L Floyd, Pearson Education. **Reference Books:** 1. Semiconductor Devices and Circuits by Aloke K Dutta, Oxford University Press. 2. Electronic Devices and Circuits by Mohammad Rashid, Cengage Learning. 3. Electronic Circuits: Discrete and Integrated by Schilling and Belove, McGraw-Hill Education. 4. Electronic Device and Circuit Theory by Robert Boylestad and Louis Nashelsky, Prentice Hall India. 5. Electronic Devices and Circuits by David A Bell, Oxford.

Mapping of CO (Course outcomes) with PO (Program Outcomes)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO#1	3	3	3	2	2	-	-	-	-	-	-	3
CO#2	2	2	3	2	3	1	-	-	-	-	-	2
CO#3	2	2	3	3	3	2	1	-	-	-	-	2
CO#4	2	3	2	3	3	-	-	-	-	-	-	-
CO#5	2	3	3	3	3	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 are defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>PHC332</td><td>Electromagnetic Field Theory</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
</table>

Course Outcomes	CO1: Able to apply fundamental knowledge of different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory. CO2: Able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.). CO3: Gain an integrative overview of electromagnetic waves, its propagation in different media and different phenomena related to electromagnetic wave propagation. CO4: Acquire basic knowledge related to wave guides and transmission line.
Topics Covered	**Concept of Field and Maxwell's Equations** Vector field, Divergence of vector field, Divergence of electrostatic field, Gauss's divergence theorem, Gauss's Law of electrostatics and its applications, Laplace's equation, Poisson's equation, Continuity equation. [7] Curl of a vector field, Stoke's theorem, Curl of magnetic field, Ampere's Circuital law and its applications, Curl of electric field and divergence of magnetic field, Concepts of scalar and vector potentials. [7] Faraday's law of electromagnetic induction, Self-Inductance, Mutual-Inductance, L-C-R Circuit, Concept of displacement current, Maxwell's equation in free space, Poynting theorem. Some examples. [9] **Electromagnetic Waves** Derivation of the electromagnetic wave equation. Plane waves in vacuum. Energy, Momentum and intensity of electromagnetic waves. Electromagnetic waves in isotropic, Anisotropic medium, Conducting medium. Skin effect. Propagation of electromagnetic waves in ionized gases, Reflection, Refraction and Dispersion of electromagnetic waves, Fresnel's equations. Some examples. [12] **Wave Guide** Wave guides, TE, TM and TEM waves, Transmission line and Telegrapher's equation. [7]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Introduction to Electrodynamics, David J. Griffiths, Prentice-Hall International, Inc., Englewood Cliffs. 2. Foundations of Electromagnetic Theory, J. R. Reitz, F. J. Milford and R. W. Christy, Addison-Wesley Publishing Company, Inc. 3. Introduction to Electromagnetic Theory – A Modern Perspective, T. L. Chow, Jones and Bartlett Publishers, Inc. **REFERENCE BOOKS:** 1. Classical Electricity and Magnetism, W. K. H. Panofsky and M. Phillips, Addison-Wesley. 2. Classical Electrodynamics, W. Greiner, Springer International Edition 3. Classical Electrodynamics, J. D. Jackson, John Wiley

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC332	CO1	3	2	-	1	1	-	-	-	2	1	-	1
	CO2	3	2	1	1	-	1	-	-	1	1	-	1
	CO3	3	2	1	1	1	-	-	-	1	1	-	1
	CO4	3	2	1	-	-	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
PHS382	**Physics Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT), and end assessment (EA))					
PHS51		CT+EA					
Course Outcomes	CO1: To realize and apply different techniques for measuring resonance, Q-factor of series L-C-R circuit. CO2: To determine the Self-Inductance, Mutual Inductance and verification of Faraday's law. CO3: To determine the thermoelectric power of a given thermocouple. CO4: To apply the concepts to measure the horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer CO5: To calculate the loss of a magnetic specimen by B-H loop measurement.						
Topics Covered	1. Study of series L-C-R Resonant Circuit: (i) To draw the resonance curve (ii) To determine the Q- Factor of the circuit (iii) To study the variation of impedance with frequency (iv) verification of maximum power transfer theorem. 2. Verification of Faraday's law. 3. To determine the mutual inductance (M) of two coils. 4. Determination of Self-Inductance of a coil. 5. To verify Fresnel's equation for reflection of electromagnetic waves. 6. Draw the (Thermo EMF) – Temperature curve of given thermocouple and hence find thermoelectric power at a given temperature. 7. Determination of horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer. 8. To draw the B-H loop of a given specimen.						
Text Books, and/or reference material	**SUGGESTED BOOKS:** 1. A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2. Practical Physics – Worsnop and Flint						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS382	CO1	3	2	1	-	2	1	1	2	3	2	1	1
	CO2	3	2	1	-	2	1	1	2	3	2	1	1
	CO3	3	2	1	1	2	1	1	2	3	2	1	1
	CO4	3	2	1	-	2	1	1	2	3	2	1	1
	CO5	3	2	1	1	1	1	1	1	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES351	ELECTRICAL & ELECTRONIC MEASUREMENT LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO 1: To measure power and energy in single phase and three phase circuit. • CO2: To understand the operation of DC potentiometer • CO3: Introduction to industrial power measurement with CT and PT • CO4: Measurement of inductance, capacitance, and capacitance by AC bridges. • CO5: To measure earth resistance • CO6: To measure displacement, force, pressure by transducers						
Topics Covered	**List of Experiments:** 1. Measurement of power in single phase circuit by three voltmeter and ammeter method 2. Measurement of power in three phase circuit by two wattmeter method 3. Calibration of DC potentiometer 4. Calibration of Energy meter 5. Measurement of power by CT and PT 6. Measurement of Earth resistance by three electrode method 7. Measurement of displacement by LVDT 8. Measurement of inductance by Anderson's Bridge 9. Measurement of capacitance by Schering Bridge 10. Measurement of frequency Wien's Bridge						
Textbooks, and/or reference material	Suggested Textbooks: 1. Electrical Measurements & Measuring Instruments by Golding &Widdis, Wheeler's Student Edition 2. Electronic Instrumentation by HS Kalsi, Tata McGraw- Hill Suggested Reference Books: 1. A course in Electrical and Electronic Measurements and Instrumentation by A.K.Sawhney, Dhanpat Rai & Co.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	1	1	1	2	2	3
CO2	3	3	3	3	3	2	1	1	1	2	2	3
CO3	3	3	3	3	3	3	2	2	2	2	2	3
CO4	3	3	3	3	3	1	1	1	1	2	2	3
CO5	3	3	3	3	3	3	2	2	2	2	2	3
CO6	3	3	3	3	3	2	1	1	3	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EEC401	Power Systems - I	3	1	0	4.0	4
2	EEC402	Electrical Machines - I	3	1	0	4.0	4
3	EEC403	Digital Electronics	3	1	0	4.0	4
4	MEC431	Fluid and Thermal Engineering	3	0	0	3.0	3
5	YYO44*	Open Elective - I	3	0	0	3.0	3
6	EES451	Network Analysis and Synthesis Laboratory	0	0	3	1.5	3
7	ECS481	Analog Electronics Laboratory	0	0	3	1.5	3
8	MES481	Fluid and Thermal Engineering Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**3**	**9**	**22.5**	**27**

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC401	POWER SYSTEMS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC 301 (NETWORK ANALYSIS AND SYNTHESIS)		CT+MT+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: find out economical voltage, minimum consumer voltage for different kinds of loads for transmission of electrical energy and suggest remedy to improve the voltage if needed. • CO2: evaluate different parameters associated with electrical design and mechanical design of transmission line including the presence of neighboring communication lines. • CO3: analyze the performance of short, medium, long distance transmission lines. • CO4: apply the knowledge to find out different important parameters of insulators and know different methods to improve the performance parameters of the insulators. • CO5: select the appropriate type of power cables to be used for different applications and determine operating voltage, charging current, charging kVAR, insulation resistance, and dielectric power loss of power cables. • CO6: mitigate different adverse situation that may arise due to corona.						
Topics Covered	Distribution Systems: Systems of distribution, economics and copper efficiencies, calculations on distribution and feeders, Kelvin Law. (10) Electrical Design of Overhead Lines: Conductor materials, resistance, inductance, self and mutual GMD calculations for single, twin and multi- circuit lines including bundled conductors, cases of symmetrical and unsymmetrical lines. Capacitance: calculation for single twin and multi circuit lines effect of earth. Choice of transmission voltage, influencing factors, spacing between conductors, current rating of overhead lines. (10) Mechanical Design of Overhead Lines: Mechanical properties of different types of overhead conductors, factors of safety in relation to working conditions, calculation of sag. Supports at different levels: effect of change of temperature and loading: sag						

	templates and stringing charts. Supports for overhead lines: low voltage high voltage and extra high voltage lines. Span length: basic and economic spans. Ground clearance of conductors. (6) Insulators: Materials used, types of insulators for low voltage, high voltage and extra high voltage lines and outdoor switchyard, bushing insulators, voltage distribution in a string of suspension insulators, methods of potential equalization; arching horns and grading rings, reasons of overhead line insulator failure, puncture and flashover voltage, design criteria. (7) Insulated Cables: Types of L. V. Cables for distribution systems: conductor materials, important types of insulating materials, high voltage cables, Stresses developed, economical stress and grading of dielectric materials, screened and pressure cables, mechanism of cable break down charging Current, power factor and losses in cables, determination of current Rating of cables. (8) Transmission and Performance: Classification of transmission lines, calculation of regulation and efficiency, Nominal T. Nominal II and rigorous methods, generalized circuit parameters (A,B,C and D constants) Ferranti effect and losses in open circuited lines. Calculation of phase modifier capacity. (7) Corona: Reasons for corona, critical disruptive voltage and visual critical voltage Effects of pressure, temperature and irregularity of conductor surface, Losses in corona and its reduction. (4) Inductive interference: Electrostatic and electromagnetic interference with adjacent lines. (4)
Textbooks, and/or reference material	Textbooks: 1. The Transmission and Distribution of Electrical Energy by H. Cotton & H. Barber,Publisher: Hodder Arnold,ISBN 13: 9780340147719, ISBN 10 : 0340147717. 2. Power System Analysis by D. P. Kothari & I. J. Nagrath,Publisher: Tata McGraw Hill Education,ISBN: 0-07-049489-4 Reference Book: 1. Power system analysis by John J. Grainger & William D. Stevenson,Publisher: Tata McGraw Hill Education,ISBN 10: 0070585156, ISBN 13: 978-0070585157

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	1	1	1	1	0	1	1
CO2	2	2	3	1	2	2	1	0	1	0	1	1
CO3	2	2	3	2	2	2	1	0	1	0	1	1
CO4	2	2	2	1	2	2	1	0	1	0	1	1
CO5	2	2	2	1	2	2	1	0	1	0	1	1
CO6	2	2	1	1	2	1	1	0	1	0	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit	
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours		
EEC402	ELECTRICAL MACHINES - I	PCR	3	1	0	4	4	
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))						
EEC01 (ELECTRICAL TECHNOLOGY)		CT+MT+EA						
Course Outcomes	• CO 1: Able to understand the fundamental principles and classification of electromagnetic machines. • CO2: Ability to design an armature winding • CO3: Able to learn about the constructional details and principle of operation of dc machines. • CO4: Acquire knowledge about the working of dc machines as generators and motors. • CO5: Acquire knowledge about the constructional details, principle of operation of transformers. • CO6: Acquire knowledge about testing and applications of dc machines & transformers.							
Topics Covered	DC Machines: Armature winding: Lap winding, wave winding, equalizer rings. (8) Generator: Construction of dc machines, Emf equation, types of generators, losses, efficiency, armature reaction, commutation, interpoles, compensating windings, dc generator characteristics, voltage build-up of a dc shunt generator, parallel operation of dc generators. (12) Motor: DC motor principle, counter Emf, speed and torque equations, load characteristics, speed control, starting of dc motors, three-point and four-point starters, testing of dc machines. (12) Transformer: Single-phase transformer: Construction and types, principle of operation, Emf equation, transformer on no-load, transformer on load, equivalent resistance, magnetic leakage, equivalent circuit, phasor diagram, open and short circuits tests, voltage regulation, losses, efficiency, all-day efficiency, separation of hysteresis and eddy current losses, parallel operation, auto transformer. (12) Three-phase transformer: Three-phase transformer connections and vector groups, equivalent circuit, determination of equivalent circuit parameters, parallel operation, three phase to two-phase conversion and vice-versa, tap-changers on transformers, testing of transformers, cooling. (12)							
Textbooks, and/or reference material	Textbooks: 1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc. 2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill. Reference Books: 1. M.G. Say, Alternating Current Machines, Pitman Publishing. 2. Alexander S. Langsdorf, Theory of Alternating Current Machinery, Tata McGraw-Hil							

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	2	1	1	2	1	2	1
CO2	3	3	3	3	3	3	2	1	2	2	2	2
CO3	3	2	3	2	2	2	1	1	1	1	2	2
CO4	2	2	2	3	2	2	1	1	1	1	2	2
CO5	3	3	3	2	2	2	1	2	1	1	2	3
CO6	3	3	3	3	2	2	2	2	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC403	DIGITAL ELECTRONICS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Nil		CT+MT+EA					

Course Outcomes	• CO 1: Acquire an idea about digital electronics and its applications. • CO2: To learn the fundamentals of different numbers of systems and codes and code conversion techniques. • CO2: To study about the Boolean algebra and basic logic gates along with their digital design procedure using elementary logic gates. • CO3: To learn about the different sequential and combinational logic circuits and their use in digital electronics applications. • CO4: Learn about the Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), and data conversion and acquisition techniques. • CO5: To study the different types of Codes (Gray code, Excess-3 code, BCD Code etc.) and Code converters
Topics Covered	Introduction to Digital Electronics: History and Evolution of Computation and Computers, Application of Digital Electronics in Modern Society. (4) Number Systems and Codes: Decimal Number System, Binary Numbers System, Octal Number System, Hexadecimal Numbers System, Numbers Conversions, Gray Code, Excess-3 Code, BCD Code, Hamming Code, Code Conversion, BCD to 7-Segment Decoder: Error Detection and Correction Codes - error detection by parity checking, Principle of error correction. (6) Boolean Algebra and Logic Gates: Binary arithmetic, Binary Addition, Binary Subtraction, Binary Multiplication, Binary Division, 1s Complement, 2s Complement, Signed Binary Number, Introduction to Logic Gates, Basic Logic Gate Operations, Universal Gates, Realization of logic gates using switches. (6) Digital Arithmetic and Arithmetic Circuits: Half Adder, Full Adder, Half Subtractor, Full Subtractor, Multi-Bit Ripple-Carry Adder and Subtractor circuits, Basics of Binary Multiplier and Divider Circuits. (5) Logic Families: Transistors (MOS and BJT) as switch, Different logic families such as RTL,

	DCTL, DTL, HTL, TTL, ECL, MOS & CMOS logic family their importance and applications. (5) Minimization Techniques Logic Synthesis: Demorgan's Theorem, SOP/POS forms, Minimization of logical function, Algebraic method, Karnaugh Map method, Quine Mccluskey Method. (6) Combinational Circuits: Multiplexer, Demultiplexer, Decoder, Encoder, Decoder Driver, Combinational Circuit Design and Their Applications. (6) Sequential Circuits: Definition, Moore and Miley Machines; Elements of Sequential Circuits - Latches and Registers, Different kinds of Flip-Flops - R-S, J-K, Master-Slave arrangement, D, and T Type Registers; Typical sequential circuits -counters, shift registers and sequence generator; synchronous and asynchronous circuits. (8) Multivibrators: Definition of different types of Multivibrators, their realization by logic gates, op-amp and transistors, 555 Timer IC and Schmitt Trigger circuit and their applications. (6) A/D & D/A Converter: Need for Data conversion, Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), and data conversion and acquisition techniques, Different types of DAC & ADC ICs, data conversion and acquisition techniques, Introduction to GUI and PC Based Data Acquisition Systems, Data Acquisition System Components (Software and Hardware).(4)
Textbooks, and/or reference material	Textbooks: 1. Fundamentals of Digital Logic - Anand Kumar – PHI 2. Digital Electronics - G. K. Kharate– Oxford 3. Digital Logic and Computer Design - M. Morris Mano – PHI Reference Books: 1. Digital Fundamentals - Floyd, UBS 2. Digital Systems: Principles and Applications - Tocci, Widmer and Moss, Pearson Edu.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	2	1	1	1	1	1	1	1
CO2	2	3	3	3	3	1	2	1	2	0	2	1
CO3	2	3	3	3	3	0	2	1	2	0	2	0
CO4	2	3	3	3	3	2	1	1	2	0	2	2
CO5	2	2	2	2	2	1	1	3	2	0	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the Course	Programme core (PCR)/Electives (PEL)	Total number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC-431	Fluid and Thermal Engineering	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Knowledge of Engineering Mechanics, Differential Equations etc	CT+MT+EA

Course Outcomes	• Co1: Study of fundamentals of Fluid Mechanics • Co2: Understanding the principles of Hydraulic Machines such as Pelton Turbine in energy conversion • Co3: Principle of Reciprocating and Centrifugal pump • Co4: Study of basics of Thermodynamics • CO5: Study of principle of steam turbine, boiler etc.
Topics Covered	Definition of fluid, Difference between solid and fluid, Continuum Concept, Knudsen No, density, specific volume, bulk modulus, compressibility of fluid. (01) Viscosity, Newton's law of viscosity, different types of fluid, effect of pressure and temperature on viscosity, numerical problem. (02) Fluid pressure, hydrostatic law of pressure, pressure variation with space in static fluid, absolute, gauge and vacuum pressure, pressure measuring devices, numerical problem. (03) Fluid kinematics, definition of flow field, Lagrangian and Eulerian approach of describing fluid motion. (01) Representation of velocity and acceleration in Cartesian coordinate, temporal, convective and total acceleration. (01) Steady and unsteady flow, uniform and non-uniform flow, laminar and turbulent flow, flow visualisation, stream line and path line. (01) Differential form of continuity equation in cartesian coordinate for compressible and incompressible flow. (01) Derivation of Euler's equation along a stream line, Bernaullis equation, pressure head, kinetic head and datum head. (01) Application of Bernaullis principle, flow measuring device, venturimeter, orifice meter and pitot tube, numerical problems. (03) Hydraulic machines, dynamic force on fixed and moving vanes. (01) Turbine and its classification, Pelton turbine and its working principle, numerical problems.(01) Pump and its classification reciprocating pump and its working principle.(01) Centrifugal pump, working principle, velocity diagram, characteristics curve, numerical problem. (03) Brief study of Thermodynamics as a pre-requisite to power plant engineering Energy analysis of steady state flow system, example with mechanical power transfer to and from steady state flow devices like compressor, turbine etc. System equilibrium, requirement for internal and total reversibility, cause of effect of irreversibility, concept of heat engine, its working cycle, its efficiency with Carnot cycle, Effect of increase in saturation pressure on phase transformation, properties of steam, use of steam table, Mollier chart. (10) Basic devices in steam power plant and their schematic arrangement, fundamental concept of processes involved in them , simple Rankine cycle with steady flow of working fluid (water and

	steam),performance parameter for efficient plant operation, effect of increase in boiler pressure on operating cycle performance, internal and external irreversibility associated with various practical processes during energy and mass transfer through the devices, reheat regeneration and their combined application for improvement of plant operation, a few numerical problems, brief description of super heater, economiser in power plant. (10) Introduction to gas turbine power plant. (01)
Text books, and/or Reference material	Suggested Text Books: 1. Hydraulic and Fluid Mechanics- Jagdish Lal 2. Hydraulic Machinery- Jagdish Lal 3. Introduction to Fluid Mechanics and fluid Machines- Som and Biswas 4. Engineering Thermodynamics- P K Nag 5. Introduction to Power Plant Engineering - P K Nag References: 1. Introduction to Fluid Mechanics - Fox, Mcdonald and Pritchard

Mapping of CO (Course Outcome) and PO (Programme Outcome) for MEC-431

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	2	2	1	2	1	2	3	2	1
CO2	2	3	1	2	2	1	2	1	2	3	2	1
CO3	2	3	1	2	2	1	2	1	2	3	2	1
CO4	2	3	1	2	2	1	2	1	2	3	2	1
CO5	2	3	1	2	2	1	2	1	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES451	NETWORK ANALYSIS AND SYNTHESIS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO 1: Prepare laboratory reports that clearly communicate experimental information in a logical and scientific manner. • CO2: Students will get the basic concepts of passive components and their configurations and about how to use experimental equipment's such as function generator, CRO, regulated power supply etc. • CO3: Predict and measure the transient and sinusoidal steady-state responses of simple RL, RC and RLC circuits. • CO4: Able to apply linearity and superposition concepts to analyze RL, RC, and RLC circuits in time and frequency domains. • CO5: Able to analyze resonant circuits both in time and frequency domains. • CO6: Able to construct and make time and frequency domain measurements on elementary RL, RC, and RLC circuits.						

	• CO7: Evaluate the parameters of two port networks to analyze the performance of transmission lines • CO8: Apply computer mathematical and simulation programs to solve circuit problems.
Topics Covered	**List of Experiments:** 1. Determination of transient response of current in RL and RC circuits with step voltage input. 2. Determination of transient response of current in RLC circuit with step voltage input for under-damped, critically damped and over-damped cases. 3. Determination of frequency response of current in RLC circuit with sinusoidal ac input. 4. Determination of frequency response characteristics of a low pass and high pass active filters. 5. Determination of z and h parameters (dc only) for two port networks. 6. Determination of the driving point and transfer impedance of coupling circuit. 7. To verify different Network Theorem for ac Circuit. 8. Locus diagram of RC and RL circuit. 9. Generation of Periodic, Exponential, Sinusoidal, damped sinusoidal, Step, Impulse, and Ramp signals using MATLAB in both discrete and analog form. 10. Determination of transient and frequency response characteristics of RL, RC and RLC circuits using MATLAB. 11. Determination of frequency response characteristics of a T-network low pass and high pass passive filters using MATLAB
Text Books, and/or reference material	Text Books: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. 3. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	2	1	3	3	3	3
CO2	3	3	3	3	3	1	2	1	3	3	3	3
CO3	3	3	3	3	3	1	2	1	3	3	3	3
CO4	3	3	3	3	3	1	2	1	3	3	1	1
CO5	3	3	3	3	3	1	2	1	3	3	1	1
CO6	3	3	3	3	3	1	2	1	3	3	3	3
CO7	3	3	3	3	3	1	2	1	3	3	1	1
CO8	3	3	3	3	3	1	2	1	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="10">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Course Name</td><td rowspan="2">Program Core (PCR)/ Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS481</td><td colspan="2">Analog Electronics Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic Electronics (ECC01)
Analog Electronics (ECC331)</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO#1: Acquire knowledge of identifying analog Integrated Circuits.
CO#2: Gain knowledge of designing linear and non-linear analog circuits using transistor.
CO#3: Develop skills to design amplifiers and oscillators.
CO#4: Acquire skills to implement analog circuits using breadboard.
CO#5: Develop acquaintance to use electronic test and measurement instruments.</td></tr>
<tr><td colspan="2">List of Experiments</td><td colspan="7">Experiment:1
DESIGN AND SET UP AN RC COUPLED COMMON EMITTER AMPLIFIER USING VOLTAGE DIVIDER BIASED BIPOLAR JUNCTION TRANSISTOR TO PLOT ITS FREQUENCY RESPONSE AND DETERMINE THE GAIN-BANDWIDTH PRODUCT.
Experiment:2
DESIGN, SETUP AND PLOT THE FREQUENCY RESPONSE OF COMMON SOURCE JFET AMPLIFIER AND OBTAIN THE BANDWIDTH.
Experiment:3
DESIGN AND TEST A 1 KHZ RELAXATION OSCILLATOR USING UJT.
Experiment:4
COMPLEMENTARY SYMMETRY CLASS B PUSH PULL POWER AMPLIFIER.
Experiment:5
LINEAR APPLICATION OF OP-AMP (INVERTING AMPLIFIER, NON-INVERTING AMPLIFIER).
Experiment:6
• DESIGN AND IMPLEMENTATION OF INTEGRATOR AND DIFFERENTIATOR USING IC 741 OP-AMP.
• DESIGN AND IMPLEMENTATION OF ADDER AND SUBTRACTOR USING OP-AMP.
Experiment:7
• DESIGN AND IMPLEMENTATION OF RC PHASE SHIFT OSCILLATOR USING IC 741 OP-AMP.
• DESIGN AND IMPLEMENTATION OF WIEN BRIDGE OSCILLATOR USING IC 741 OP-AMP.
Experiment:8
DESIGN AND IMPLEMENTATION OF ASTABLE MULTIVIBRATOR USING IC 555.
Experiment:9
DESIGN AND IMPLEMENTATION OF VOLTAGE REGULATOR USING IC 723.
Experiment:10
TO STUDY SOLDERING AND DE-SOLDERING TECHNIQUES.</td></tr>
<tr><td colspan="2">References</td><td colspan="7">Reference Manuals:
1. Brian Dean, Introduction to Analog& Digital Circuits Lab Manual, Kendall Hunt Pub Co, 2018.
2. NAVAS, K. A., Electronics Lab Manual (VOLUME 1 and 2), PHI, Sixth Edition.
3. Departmental Lab Manual.</td></tr>
</table>

Mapping of CO (Course outcomes) and PO (Program Outcomes)												
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO#1	2	1	2	-	-	-	-	-	1	1	-	1
CO#2	2	3	3	2	1	-	-	-	1	1	-	1
CO#3	2	3	3	1	1	-	-	-	1	1	-	1
CO#4	1	2	3	2	1	-	-	-	2	1	-	1
CO#5	2	1	2	2	1	1	-	-	3	1	1	1

Correlation levels 1, 2 or 3 are defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Programme Core(PCR)/Electives(PEL)	Total no of contact hours				Credit
MES-481	Fluid and Thermal Engineering Sessional	PCR	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	2
			0	0	3	3	
Pre-requisites		Course Assessment methods (Continuous (CT), and end assessment (EA))					
Theory of hydraulic machine and power plant engineering		CT+EA					
Course Outcome	• Co1: Study of calibration of Venturi meter • Co2: Study the performance characteristics of Pelton and Francis turbine • Co3: Understanding the performance characteristics of centrifugal pump Co4: Understanding the function, and construction of Lancashire Boiler • Co5: Study the principle of diesel and petrol engine						
Topics Covered	1. Calibration of Venturimeter 2. Friction loss computation in pipe flow 3. Performance of centrifugal pump 4. Performance test of pelton turbine 5. Performance test of Francis turbine 6. Calibration of Vacuum gauge (Bourdon gauge tube) 7. Model study of Lancashire Boiler 8. To study the performance of 4 stroke petrol engine 9. To study the performance of diesel engine using rope brake dynamometer under variable load condition.						
Text books, and/or Reference material	Suggested Text Books: 1. Introduction to Fluid Mechanics-Fox, Mcdonald and Pritchard 2. Introduction to Fluid Mechanics and fluid Machines- Som and Biswas 3. Introduction to Power Plant Engineering - P K Nag Suggested Reference Books: Fluid Mechanics- J F Douglas, J M Gasiorek, J A Swaffied, L B Jack						

Mapping of CO (Course Outcome) and PO (Programme Outcome) for MES-481

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	3	2	1	2	1	3	2	2	2
CO2	2	3	1	3	2	1	2	1	3	2	2	2
CO3	2	3	1	3	2	1	2	1	3	2	2	2
CO4	2	3	1	3	2	1	2	1	3	2	2	2
CO5	2	3	1	3	2	1	2	1	3	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject for Non-departmental Students:(4th Semester)

Subject Code	Subject Name
EEC431	**CONTROLSYSTEMENGINEERING**
EEC-432	**ELECTRICAL MACHINES**
EES481	**CONTROLSYSTEMSLABORATORY**
EES-482	**ELECTRICAL MACHINES LABORATORY**

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC431</td><td>CONTROL SYSTEM ENGINEERING</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">ECC 303(SIGNALS AND SYSTEMS)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To get the knowledge of basic objectives of control system design
CO2: To derive input-output relationship of systems based on their mathematical modeling governed by basic laws of physics
CO3: To justify stability of systems based on their transfer functions, time domain and frequency domain specifications
CO4: To develop concepts on root pattern with variable gains and comment on the stability
CO5: To determine the stability of closed-loop system based on open loop frequency response
CO6: To be able to design controllers so as to meet design specifications both in time as well as frequency domain
CO7: To be able to realize the controller both in software simulation through MATLAB coding as well as in real-time environment.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to control systems: Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (4)
Mathematical Models of Physical Systems:Concept of Linearization, Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block</td></tr>
</table>

	diagram Algebra, Signal flow graph and Mason's Gain formula. (6) **Introduction to State Variable Approach:** Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix. (4) Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (2) **Time domain analysis and design specification of linear systems:** Standard signals, Transient response and s-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (6) **Concepts of Stability and Algebraic Criterion:** Concept of stability, Concept of Stable and Unstable Characteristic equation &necessary conditions for stability, Routh-Hurwitz stability criteria. (4) **Root Locus Technique:** The concept of root locus, Analytical construction of Root Loci, Root-locus Plots with MATLAB. Design using root locus (4) **Frequency Response Analysis and Stability Studies in Frequency Domain:** Frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, conditionally stable system, M and N loci on complex and gain phase plane, MATLAB tools and case studies. (8) **Design and Compensation Techniques:** Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and s-plane design techniques, Example of control systems. Design with MATLAB. (4)
Text Books, and/or reference material	Suggested Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic Control system, John Wiley & Sons Suggested Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	2	1	3	1	2	2
CO2	3	3	3	3	2	2	2	1	3	1	1	1
CO3	3	3	3	2	2	1	2	2	3	1	1	1
CO4	2	3	2	2	1	1	2	1	2	1	1	1
CO5	3	3	3	2	2	1	3	1	2	1	1	1
CO6	2	3	3	2	3	2	3	1	3	1	1	1
CO7	2	3	3	3	3	3	3	2	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC-432</td><td>ELECTRICAL MACHINES</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: Theory of electromechanical energy conversion, the concepts of voltage generation and fundamental torque equation.
• CO2: Basic understanding of the principles of operation and construction of direct and alternating current machines and transformers.
• CO3: A study of theory and concept of Electric Machines (AC & DC).
• CO4: Deriving equivalent circuit of electrical machines.
• CO5: Studying the performance and characteristics of Electrical machines (AC & DC).</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic principle of Faraday’s law of electro-magnetic induction, energy conversion and magnetic circuit. (4)
Transformer: Construction and principle of operation of single-phase transformer, Step-up and Step-down transformer, E.M.F. equation, Equivalent circuits, phasor diagram, Open circuit and short circuit tests, losses and efficiency, All day efficiency, Auto transformer. (8)
D.C. Machines Construction, Methods of excitation and classifications, Simple lap and wave windings, emf equation, characteristics of different dc generator, armature reaction, Commutation, Back e.m.f in a d.c. motor, Motor Starter, Speed and torque equations, Speed vs torque characteristics and speed control of DC motors, losses in dc machines, Applications. (12)
Induction Motor: Pulsating and rotating magnetic field construction and principle of operation of Single and three phase induction motors, cage and wound rotor induction motors, comparison between them slip, equivalent circuits, no load and blocked rotor tests, Circle diagram, Torque/speed curve Starting and speed control, Applications of single phase and three phase induction motors. (12)
Synchronous Machines: Construction-alternators-turbo & hydro generators, principle of operation, emf equation, excitation control, synchronization load sharing synchronous motor operation, Synchronous condenser, applications of synchronous generator and motor. (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Electrical Machinery by P S Bimbhra
2. Electrical Technology Vol-II by B L Thereza
Reference Book:
1.Electrical Machines by J B Gupta</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	2	3	2	1
CO2	2	2	2	2	3	1	1	1	2	3	2	1

CO3	2	2	2	2	3	1	1	1	2	3	2	1
CO4	3	3	3	3	2	1	1	1	2	3	2	1
CO5	3	3	3	3	2	1	1	1	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES481	CONTROL SYSTEMS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), and end assessment (EA))					
ECC303(SIGNALS AND SYSTEMS)		CT+EA					
Course Outcomes	• CO 1: To understand the dynamic behaviour of real-time systems. • CO2: To simulate physical systems in real-time environment. • CO3: To design control system to improve the performance characteristics of real-time systems. • CO4: To determine the parameters and transfer function of physical systems from real-time experimentation. • CO5: To get acquainted with MATLAB programming, MATLAB-SIMULINK in order to simulate, analyze and design of control system design for different plants under consideration.						
Topics Covered	List of Experiments: 1. DC Servo Speed Control System 2. DC Servo Position Control System 3. Temperature Control System 4. Linear System Simulator 5. Lead and Lag Network 6. P, PI and PID controller 7. Study of Different real-time systems through Simulation in MATLAB 8. PID Design Method for DC motor Speed Control using MATLAB 9. Root Locus Design Method for DC motor Speed Control using MATLAB 10.DC motor Speed Control Based on Frequency Response using MATLAB						
Text Books, and/or reference material	Suggested Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age InternationalPublishers. 2. 2. K. Ogata, Modern Control Engineering, Prentice Hall. Suggested Reference Books: 1.B. Shahian, M. Hassul, Control System Design using MATLAB, Prentice Hall. Laboratory Manuals						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	2	2	1	3	1	3	3
CO2	3	3	2	3	3	3	3	1	3	1	3	3
CO3	3	3	2	3	3	2	2	1	3	1	3	3
CO4	3	3	2	3	3	2	2	1	3	1	3	3
CO5	3	3	2	3	3	2	2	1	3	1	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES-482	ELECTRICAL MACHINES LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), and end assessment (EA))					
EES51(ELECTRICAL TECHNOLOGY LAB), EEC432 (ELECTRICAL MACHINES)		CT+EA					
Course Outcomes	• CO1: Ability to determine the equivalent circuit parameters of a single-phase transformer • CO2: Ability to determine the parameters of single-phase as well as three phase induction motor. • CO3: Ability to determine the characteristics of dc shunt generator and series generator • CO4: Ability to control the speed of a dc shunt motor • CO5: Ability evaluate the voltage regulation of an alternator • CO6: Ability to determine the efficiency of dc machines						
Topics Covered	List of Experiments: 1. Determination of equivalent circuit parameters of a single-phase transformer. 2. No-load and load characteristics of a dc shunt generator. 3. Speed control of a dc shunt motor. 4. Open-circuit and load characteristics of a dc series generator. 5. Voltage regulation of an alternator. 6. To perform no-load and blocked-rotor tests on a three-phase Induction Motor. 7. To perform no-load and blocked-rotor tests on a single-phase Induction Motor. 8. Swinburne's test of a dc machine.						
Text Books, and/or reference material	Text Books: 1. Electrical Machinery by P S Bimbhra 2. Electrical Technology Vol-II by B L Thereza Reference Book: 1. Electrical Machines by J B Gupta						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	2	3	2	1
CO2	3	3	3	2	3	1	1	1	2	3	2	1
CO3	3	2	2	1	2	1	1	1	2	3	2	1
CO4	3	2	2	1	2	1	1	1	2	3	2	1
CO5	3	2	2	1	2	1	1	1	2	3	2	1
CO6	3	2	2	1	2	1	1	1	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	**EEC501**	**Electrical Machines - II**	**3**	**1**	**0**	**4.0**	**4**
2	**EEC502**	**Control Systems**	**3**	**1**	**0**	**4.0**	**4**
3	**EEC503**	**Power Systems - II**	**3**	**1**	**0**	**4.0**	**4**
4	**EEC504**	**Power Electronics**	**3**	**1**	**0**	**4.0**	**4**
5	**YYO54***	**Open Elective - 2**	**3**	**0**	**0**	**3.0**	**3**
6	**ECS581**	**Digital Electronics Laboratory**	**0**	**0**	**3**	**1.5**	**3**
7	**EES551**	**Control Systems Laboratory**	**0**	**0**	**3**	**1.5**	**3**
8	**EES552**	**Electrical Machines Laboratory - I**	**0**	**0**	**3**	**1.5**	**3**
9	**XXS581**	**Co-curricular Activities - V (Optional)**	**0**	**0**	**0**	**0.0**	**0**
		TOTAL	**15**	**4**	**9**	**23.5**	**28**

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC501</td><td>ELECTRICAL MACHINES - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC402 (ELECTRICAL MACHINES - I</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Ability to design an AC machine and distinguish it from a DC machine
CO2: Ability to determine the alternator voltage regulation
CO3: Ability to Synchronize an alternator with an infinite bus
CO4: Ability to understand the starting methodology of a synchronous motor and determine the variation of synchronous machine performance with excitation
CO5: Ability to assess performance of an induction motor based on appropriate experimentation
CO6: Ability to start an induction motor by appropriate means & controlling its speed in effective way</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Synchronous Generator: Constructional Features of Salient Pole and Non-Salient Pole Machines, Arrangement of Field Winding in the two types of Machines. Armature Winding. (5)
Cylindrical Rotor Theory: Phasor Diagram, Open Circuit and Short Circuit Characteristics, Synchronous Reactance, Load Characteristics, Zero Power Factor Characteristics, Voltage Regulation by different methods, Power Angle Characteristics. (10)
Salient-Pole Theory: Blondel’s Two-Reaction Concept, Direct Axis and Quadrature Axis Synchronous Reactance, Power Angle Characteristics, Slip Test. (3)
Parallel Operation of synchronous generators, Load sharing. (4)
Synchronous Motor: Constructional features, Methods of Starting, Phasor Diagram, Torque and Power Relations in Non-Salient Pole and Salient Pole Motors, V-Curves, Various Types of Excitations, Synchronous Condenser, Applications. (8)
Three Phase Induction Motor: Constructional Features of Slip Ring and Squirrel Cage type Motors, Principle of Operation, Flux and MMF Wave, No-Load Speed and Slip, Rotor Quantities Referred to Stator, Relationship Between Input Voltage and Current, Equivalent Circuit, Analysis of Equivalent Circuit. (4)</td></tr>
</table>

	Torque Speed Characteristics, Starting, Maximum and Full Load Torque, Condition for Maximum Torque, Regions of Stable and Unstable Operations, Effect of rotor resistance and supply frequency on Speed Torque Characteristics, Performance Characteristics, and Circle Diagram. (4) Starting of Slip Ring and Squirrel Cage Motors, High Starting Torque Motors. (3) Speed Control of induction motors. (3) Single phase induction motor: Constructional features, various types, Rotating magnetic field theory, Equivalent circuit, Determination of constants, methods of starting, Applications. (4)
Text Books, and/or reference material	Suggested Text Books: 1. A. S. Langsdorf, Theory of A. C. Machines, Tata McGraw Hill. Suggested Reference Books: 1. I. L. Kosow, Electric Machinery & Transformers, PHI. 2. E. Fitzgerald, C.M. Kingsley (Jr) and S. D. Umans, Electric Machinery, Tata McGraw Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	3	1	1	1	1	1	1
CO2	3	2	3	3	2	2	1	1	1	1	1	1
CO3	3	3	3	2	2	3	1	1	1	1	1	2
CO4	3	3	3	3	2	3	1	1	1	1	1	1
CO5	3	3	3	3	2	2	1	1	1	1	1	1
CO6	3	3	3	3	2	3	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC502	CONTROL SYSTEMS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC301 (NETW ORK ANALYSIS AND SYNTHESIS), ECC331 (ANALOG ELECTRONIC S), EEC402 (ELECTRICAL MACHINES-1), EEC403 (DIGITAL ELECTRONICS)		CT+MT+EA					
Course Outcomes	• CO1: Acquire the knowledge and skills to identify the basic elements and structures of feedback control systems. • CO2: To develop the mathematical model of the physical systems. • CO3: To analyze the time response of the open loop & closed loop systems. • CO4: To analyze the stability of control systems using different tools. • CO5: To learn frequency response analysis and stability studies in Frequency Domain • CO6: To learn control system design using various kinds of compensator & to apply computer skills with MATLAB						

	• CO7: To develop and analyze state space models
Topics Covered	Introduction to control systems: Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (6) Mathematical Models of Physical Systems: Modeling of electrical networks, modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason's Gain formula. (6) Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (4) Time domain analysis and design specification of linear systems: Standard signals, Transient response and S-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (8) Concepts of Stability and Algebra Criterion: Concept of stability, characteristic equation necessary conditions for stability, Routh-Hurwitz stability criteria. (4) Root Locus Technique: The root locus concept, construction of Root Loci, Important properties parameters design by Root locus method, Root-locus Plots with MATLAB. (6) Frequency Response Analysis and Stability Studies in Frequency Domain: frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, conditionally stable system, M and N loci on complex and gain phase plot MATLAB tools and case studies. (10) Design and Compensation Technique: Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and S-plane design techniques, Example of control systems. Design with MATLAB. (6) Introduction to State Variable Approach: Concepts of state, state variables and state model state models for linear Continuous-time systems, state transition matrix, Controllability and Observability. (6)
Text Books, and/or reference material	Text Books: 1.J. Nagrath and M Gopal, Control system Engineering, New Age International Publishers 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic control system, John Wiley & Sons Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, Prentice Hall.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	1	2	1	2	1	3	3
CO2	3	3	2	3	3	1	2	1	2	1	3	1
CO3	3	3	2	3	3	2	2	1	2	1	2	1
CO4	3	3	2	3	3	2	2	1	2	1	2	1
CO5	3	3	2	3	3	2	2	1	2	1	2	1
CO6	3	3	2	3	3	2	2	1	2	1	3	3
CO7	3	3	2	3	3	2	2	1	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="10">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC503</td><td>POWER SYSTEMS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC401(POWER SYSTEMS – I)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: analyze the behavior of the power systems under symmetrical and unsymmetrical fault conditions and select suitable protective schemes and circuit breakers, in addition to deployment of suitable current limiting reactors at strategic locations for expansion of the existing systems.
CO2: select bus bar arrangements suitable for any particular application in substations or generating stations. Besides, they also become acquainted with the layout of substation equipment.
CO3: be familiarized with different types of circuit interrupting devices along with their constructions, properties, operating principles, testing and appropriate placements.
CO4: be acquainted with various types of relays and their deployment, their characteristics, connections etc.
CO5: understand and design the diverse schemes used in practice to protect power systems transmission lines, generators, transformers, bus bars etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Short circuit calculation: Symmetrical and asymmetrical short circuits, factors influencing short circuit capacity, methods of limiting short circuit levels. Symmetrical components, sequence impedance, analysis of unsymmetrical short circuit in power systems, methods of measuring sequence components for protective relays. (15)
System of Bus bars: Different bus bar arrangements, indoor and outdoor substations, bus bar materials spacing etc. conventional layout representation. (6)
Circuit Interruption Devices: Fuses and their characteristics, circuit breakers, arc characteristics, mechanism of arc extinction, current chopping, resistance switching, L.V. air and oil circuit breakers H.V. oil circuit breakers, Air blast circuit Breakers for H.V. and E.H.V. systems, Sulphur Hexafluoride (SF6) circuit breaker, Vacuum circuit breaker, Multi break devices, miniature circuit breakers, Circuit breaker contacts, material and construction rating of circuit breakers, testing and maintenance. (8)
Protective Relays: Basic requirement of protective relays and classification on their application and principle of operation. Over current relays, directional relays, characteristics and connections. Distance relays, impedance, reactance and mho relays. Differential relays, percentage differential relays, biased beam relay, Translay relay, negative sequence relay,static relays. (12)
Protective Relaying Schemes: Protection of alternators and transformers, circulating current protection, Relay plug setting and time multiplier setting. Busbar, feeders and transmission line protection time graded protection differential protection distance protection and carrier current protection. (15)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. The Art and Science of Protective Relaying, by: C. R. Mason, Published by: Wiley Eastern Limited, ISBN: 978-81-7409-232-3
2. Relays: Their Theory and Practice, by: A. R. Van C. Warrington, Publisher: Springer, ISBN: 9780412153808, 0412153807
Reference Books:
1. Switchgear Protection and Power Systems, by: S. S. Rao, Publisher: Khanna Publishers,</td></tr>
</table>

	ISBN: 978-81-7409-232-3 2. Power System Engineering, by: D. P. Kothari and I. J. Nagrath, Publisher: Tata McGraw Hill, ISBN: 9780070647916

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	2	1	1	0	1	0	1	1
CO2	2	2	3	2	2	1	1	0	1	0	1	1
CO3	2	2	2	3	2	1	1	0	1	0	1	1
CO4	2	3	3	2	2	1	1	0	1	0	1	1
CO5	2	3	3	3	2	2	1	0	1	0	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC504</td><td>POWER ELECTRONICS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">ECC331 (ANALOG ELECTRONICS), EEC403 (DIGITAL ELECTRONICS)</td><td colspan="7">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: Acquire an idea about semiconductor devices
• CO2: To learn the detail operation of the ac-dc components
• CO3: To learn the detail operation of the dc-dc components
• CO4: To learn the detail operation of the dc-ac components
• CO5: To learn the detail operation of the ac-ac components
• CO6: To identify the utilization of the components in Industry</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Characteristics and specifications, operations, V-1 characteristics, two transistor analogy, Turn OFF and Turn ON characteristics, Series and Parallel operation of Thyristors, Protection against over voltage and overcurrent, Thermal characteristic protection against dv/dt and di/dt, commutation methods of Thyristors. Different triggering circuits and their design. Similar characteristics for BJT, MOSFET, IGBT (12)
Uncontrolled rectifiers: Single phase and multiphase different circuit arrangements and their operation, analysis, performance evaluations. (6)
Controlled rectifier: Semi Controlled and fully controlled converters, single phase and multiphase, different circuit arrangements and their operation analysis performance evaluations. (7)
DC-DC Converters: Classification, principles of operation, step down (Buck) and step up (Boost) switched mode power supply, Buck-Boost Converter, H-bridge converter, their analysis, design, performance evaluation, applications. (12)
Inverters: Classification, theory of operation, 1200, 1800 mode of conduction, PWM switching topology, performance evaluation, applications. (12)
AC-AC voltage regulator using Thyristor and TRIAC, Cycloconverters: Theory and their applications. (5)
Industrial applications. (2)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. B. K. Bose, Power Electronics and AC Drives, Prentice- Hall 2. N. Mohan, T. M. Underland&Riobbins, Power Electronics: Converters, Applications & Design, John-Wiley. Reference Books: 1. L. Umanand, Power Electronics, Essentials & Applications, Wiley India Pvt. Ltd. 2. Robert W. Erickson & D. Maksimovic, Fundamentals of Power Electronics, Springer International Editio

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	1	3	1	2	1	3	3
CO2	3	3	3	2	3	1	3	1	2	1	3	3
CO3	3	3	3	2	3	1	3	1	2	1	3	3
CO4	3	3	3	2	3	1	3	1	2	1	3	3
CO5	3	3	3	2	3	1	3	1	2	1	3	3
CO6	1	3	3	3	3	2	3	2	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS581	**Digital Electronics Laboratory**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)):					
Basic Electronics (ECC01) Digital Electronics (EEC403)		Assignments and End Semester Examination					
Course Outcomes	**CO#1**: Understand digital circuits as basic building blocks of electrical communication, control system with enhanced problem solving skills. **CO#2**: Enrich knowledge of historical developments with facts that led to Integrated Circuits domain. **CO#3**: Design and develop complex digital circuits for electronics appliances. **CO#4**: Develop subsystems for the design of digital computers.						
Topics Covered	**Experiment :1** • DESIGN OF HALF ADDER AND HALF SUBTRACTOR CIRCUIT USING NAND GATES ONLY. • DESIGN OF 5-BIT EVEN / ODD PARITY CHECKER CIRCUIT USING XOR GATE. **Experiment: 2** • REALIZATION OF MULTIPLEXER AS UNIVERSAL LOGIC GATE. • DESIGN FULL ADDER AND FULL SUBTRACTOR CIRCUIT USING4:1 MULTIPLEXER. **Experiment: 3** • REALISING A BCD TO DECIMAL DECODER CIRCUIT USING DECODER DRIVER AND SEVEN SEGMENT LED DISPLAY. • VERIFYING THE FUNCTION TABLE OF 8 TO 3 LINE PRIORITY ENCODER. **Experiment: 4**						

	• DESIGN OF FOUR BIT ONE'S COMPLEMENT BINARY ADDER / SUBTRACTOR CIRCUIT. • DESIGN OF FOUR BIT TWO'S COMPLEMENT BINARY ADDER / SUBTRACTOR CIRCUIT. • DESIGN OF FOUR AND FIVE BIT DIGITAL MAGNITUDE COMPARATOR. **Experiment: 5** • VERIFICATION OF EXCITATION TABLE OF J-K FLIP-FLOP. • VERIFICATION OF EXCITATION TABLE OF D FLIP-FLOP. • DESIGNS OF T TYPE FLIP-FLOP FROM D TYPE FLIP-FLOP. **Experiment: 6** • DESIGN OF ASYCHRONOUS UP COUNTER USING J-K FLIP-FLOP. • DESIGN OF SYCHRONOUS UP COUNTER USING D FLIP-FLOP. **Experiment: 7** • STUDY OF ASYNCHRONOUS DECADE COUNTER IC7490 IN DIFFERENT MODES. • STUDY OF ASYNCHRONOUS BINARY COUNTER OR MOD 16 COUNTER IC7493 IN DIFFERENT MODES. **Experiment: 8** • STUDY OF SYNCHRONOUS DECADE COUNTER IC74160 IN DIFFERENT MODES. • STUDY OF SYNCHRONOUS UP / DOWN COUNTER IC74192. **Experiment: 9** • STUDY OF 64-BIT READ / WRITE MEMORY. • STUDY OF 4-BIT UNIVERSAL SHIFT REGISTER. **Experiment: 10** • STUDY OF 4-BIT ARITHMATIC LOGIC UNIT.
Text Books, and/or reference material	**Text Books:** 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003. **REFERENCES** 1. John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002. 2. Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2004. 3. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982. 4. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2005 5. Donald D. Givone, Digital Principles and Design, TMH, 2016. 6. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

Mapping of CO (Course outcomes) with PO (Program Outcomes)

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	1	1	-	-	-	-	-	1	1	1
CO#2	3	3	2	2	1	-	-	-	-	1	-	-
CO#3	3	3	2	2	1	-	-	-	-	1	-	-
CO#4	3	2	-	1	-	-	-	-	-	-	-	-

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES551	CONTROL SYSTEMS LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT)and end assessment (EA))
EEC301 (NETW ORK ANALYSIS AND SYNTHESIS) ECC 331 (ANALOG ELECTRONIC S), EEC402 (ELECTRICAL MACHINES- 1), EEC403 (DIGITAL ELECTRONICS)	CT+EA

Course Outcomes	• CO1: To understand the dynamic behavior of real-time systems. • CO2: To simulate physical systems in real-time environment. • CO3: To design control system to improve the performance characteristics of real-time systems. • CO4: To determine the parameters and transfer function of physical systems from real-time experimentation. • CO5: To get acquainted with MATLAM programming, MATLAB-SIMULINK in order to simulate, analyze and design of control system design for different plants under consideration.
Topics Covered	List of Experiments 1. DC Servo Speed Control System 2. DC Servo Position Control System 3. Temperature Control System 4. Process Simulator 5. Linear System Simulator 6. Lead and Lag Network 7. P, PI and PID controller 8. Determination of Transfer Function of DC Motor 9. Study of Different real-time systems through Simulation in MATLAM environment. 10.PID Design Method for DC motor Speed Control using MATLAB 11.Root Locus Design Method for DC motor Speed Control using MATLAB 12.DC motor Speed Control Based on Frequency Response using MATLAB
Text Books, and/or reference material	Suggested Text Books: 1. J.Nagrath and M Gopal, Control system Engineering, New Age InternationalPublishers. 2. K. Ogata, Modern Control Engineering, Prentice Hall Suggested Reference Books: 1. B. Shahian, M. Hassul, Control System Design using MATLAB, PHI. Lab Manuals

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	2	2	1	3	1	1	1
CO2	3	3	2	3	3	2	2	1	3	1	1	1
CO3	3	3	2	3	3	2	2	1	3	1	1	1
CO4	3	3	2	3	3	2	2	1	3	1	1	1
CO5	3	3	2	3	3	2	2	1	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES552	ELECTRICAL MACHINES LABORATORY - I	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT)and end assessment (EA))
EES51 (ELECTRICAL TECHNOLOGY LAB.), EEC402 (ELECTRICAL MACHINES-I)	CT+EA

Course Outcomes	• CO1: Ability to determine the equivalent circuit parameters and evaluate the efficiency of a single-phase transformer • CO2: Ability to connect three single-phase transformers as a three-phase transformer in different configurations • CO3: Ability to determine the characteristics of dc shunt and series generators • CO4: Ability to start and control the speed of a dc shunt motor • CO5: Ability to connect two single-phase transformers in parallel • CO6: Ability to determine the losses in a dc machine and evaluate the efficiency.
Topics Covered	List of Experiments: 1. Determination of equivalent circuit parameters of a single-phase transformer. 2. No-load and load characteristics of a dc shunt generator. 3. Speed control of a dc shunt motor. 4. Open-circuit and load characteristics of a dc series generator. 5. Ward Leonard method of speed control of a dc shunt motor. 6. Three-phase transformer connections. 7. Parallel operation of single-phase transformers. 8. Swinburne's test of a dc machine.
Text Books, and/or reference material	Text Books: 1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc. 2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill. Reference Books: 1. M.G. Say, Alternating Current Machines, Pitman Publishing. 2. Laboratory manuals

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	2	1	1	1	2	2	2	2
CO2	3	2	2	2	2	1	1	2	2	2	1	1
CO3	3	2	2	3	1	2	1	1	2	2	2	1
CO4	3	2	2	2	1	1	1	2	2	2	1	2
CO5	3	2	2	3	1	2	1	1	2	2	1	2
CO6	2	2	2	2	1	1	1	1	2	2	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Semester - VI						
Code	**Subject**	**L**	**T**	**S**	**C**	**H**
HSC631	**Economics and Management Accountancy**	**3**	**0**	**0**	**3.0**	**3**
EEC601	**Advanced Power Systems**	**3**	**1**	**0**	**4.0**	**4**
EEC602	**Microprocessor and Microcontroller**	**3**	**1**	**0**	**4.0**	**4**
EEE610 --	**Depth Elective - 1**	**3**	**0**	**0**	**3.0**	**3**
EEE610 --	**Depth Elective - 2**	**3**	**0**	**0**	**3.0**	**3**
EES651	**Electrical Machines - II Laboratory**	**0**	**0**	**3**	**1.5**	**3**
EES652	**Power Electronics Laboratory**	**0**	**0**	**3**	**1.5**	**3**
EES653	**Power System Laboratory**	**0**	**0**	**3**	**1.5**	**3**
XXS681	**Co-curricular Activities - VI (Optional)**	**0**	**0**	**0**	**0.0**	**0**
	TOTAL	**15**	**2**	**9**	**21.5**	**26**

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	Economics and Management Accountancy	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes

- CO1: To review basic economic principles with students.
- CO2: To introduce students' basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works.
- CO3: Enable the students to gain a good knowledge of financial accounting so that to enable them to prepare, analyses and interpret financial statements for taking business decisions.

Topics Covered

PART 1: Economics

Group A: Microeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Economics: Basic Concepts	2	0	0	2	2
Unit 2:	Theory of Consumer Behavior	3	0	0	3	3
Unit 3:	Theory of Production, Cost and Firms	3	0	0	3	3
Unit 4:	Analyses of Market Structures: Perfect Competition	3	0	0	3	3
Unit 5:	Monopoly Market	2	0	0	2	2
Unit 6:	General Equilibrium & Welfare Economics	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

Group B: Macroeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Macroeconomic Theory	2	0	0	2	2
Unit 2:	National Income Accounting	3	0	0	3	3
Unit 3:	Determination of Equilibrium Level of Income	4	0	0	4	4
Unit 4:	Money, Interest and Income	2	0	0	2	2

	Unit 5:	Inflation and Unemployment	2	0	0	2	2
	Unit 6:	Output, Price and Employment	2	0	0	2	2
		TOTAL	**15**	**0**	**0**	**15**	**15**
		PART 2: Management Accountancy					
	Sl. No.	**Name**	**L**	**T**	**P**	**Cr**	**H**
	Unit 1:	**Introduction to Accounting**: Accounting Environment of Business; Objectives of Accounting; Accounting Equations and principles. Books of Accounting: Journal, Ledger, Cash book.	4	0	0	4	4
	Unit 2:	**Financial Statement Preparation and Analysis:** Preparation of Trial Balance, Trading, Profit & Loss account and Balance Sheet. Case study discussion.	5	0	0	5	5
	Unit 3:	**Financial Ratio Analysis:** Common Size Statements; Computation of Financial Ratios; Interpretation and analysis of Financial Ratios with the help of case studies.	5	0	0	5	5
		TOTAL	**14**	**0**	**0**	**14**	**14**
Text Books, and/or reference material	**PART 1: Economics** **Group A: Microeconomics** 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics **Group B: Microeconomics** 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. SoumyenSikder: Principles of Macroeconomics **PART 2: Management Accountancy** 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.						

CO-PO MAPPING of Economics and Management Accountancy (HSC631)

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	-	-	-	1	-	-	-	-	-	2	3	-

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC601</td><td>ADVANCED POWER SYSTEMS</td><td>PCR</td><td>4</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC401 (POWER SYSTEM-1), EEC503 (POWER SYSTEM-1I)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand basics of High Voltage Engineering & power system stability
• CO2: To design the insulation systemand load management module
• CO3: To design the High Voltage test system and Laboratory
• CO4: To learn about the testing of High Voltage power apparatus and to understand on line monitoring and conditioned monitoring
• CO5: Given specification of stability analysis leads to modeling of power system equipment’s like transmission line, generator and design system to obtain operating limits to satisfy the reliability criteria.
• CO6: Given specification leads to knowledge of regulation of active, reactive power and frequency of any system and its application in optimal load flow and scheduling</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overview of Insulation, Air as an Insulation, Concept of Dielectric Strength, Electric field and electrode configuration, Parameters responsible for Break down Voltage of Insulating material (4)
Introduction to Breakdown of Insulation. Breakdown mechanism of insulting systems of Gas, Liquid, Solid, and Vacuum (7)
Generation of AC high voltages and DC High Voltages, Generation of impulse voltages and currents: - Analysis of different circuits, Marx multi-stage impulse generator (8)
Testing of High Voltage power Apparatus. Brief reviews of high voltage testing-Methods for High Voltage Power Apparatus, Introduction to Lightning phenomenon, Insulation Coordination. (5)
Introduction to partial discharge phenomena and concepts of Online testing (3)
Planning and Designing of High Voltage laboratory, Introduction of High Voltage virtual Laboratory (HVVL) and ICT enabled High Voltage laboratory (3)
HVDC Transmission: Introduction, classification, Stability limits, HVDC cable transmission, economic comparison, conversion of three phase AC line to DC line, Advantages of HVDC transmission, Economic distance of HVDC transmission, components of an HVDC transmission (4)
HVDC Converter station, converter unit, converter transformer, filters, reactive power source, smoothing reactor, HVDC system pole, ground electrodes, back-to-back HVDC station, two terminal HVDC systems, Multi terminal DC systems, DC circuit breakers, Limitations of HVDC transmission, application of HVDC transmission. (7)
Load flow studies: Network model formulation, Gauss- Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods. (4)
Economic operation of power system: Incremental fuel cost, economic dispatch neglecting transmission losses, General loss formula, Optimum load dispatch considering transmission losses. (3)
Power system stability: Steady state stability, transient stability, Infinite bus, stability limit, power angle curve, swing equation, swing curve, M and H constants, equivalent systems equal area criteria, multi machine stability concept and methods for improving stability. (8)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. C.L.Wadhwa, High Voltage Engineering 2.M S Naidu &Kamraju, High Voltage Engineering Reference Books: 1. D.P. Kothari & I.J. Nagrath, Modern Power System Analysis, Tata Mc-Graw Hill 2. Subir Ray, Electrical Power Systems, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	2	2	2	2
CO2	3	2	2	2	2	2	2	2	2	2	2	2
CO3	3	2	2	3	3	3	2	2	2	2	2	2
CO4	3	2	3	3	3	3	2	2	2	2	2	2
CO5	3	3	3	2	2	2	2	2	2	2	2	2
CO6	3	2	2	1	1	2	1	2	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC602	MICROPROCESSOR & MICROCONTROLLER	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC403 (DIGITAL ELECTRONICS)		CT+MT+EA					

Course Outcomes	• CO 1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller. • CO2: Describe key H/W and S/W attributes of microprocessors/microcontrollers. • CO3: Outline of the major architectural features of microprocessors. • CO4: Identify-and exercise-opportunities for hardware and software trade-offs. • CO5: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor-based system.
Topics Covered	Fundamentals of digital and microprocessors-based systems. (6) Basic microprocessor architectures, organizations and functional components. Instruction sets, assembly language programming, Micro operations of instructions. (10) Memory Classification: ROM, EPROM, EEPROM, RAM, Memory Interfacing with 8085, Address decoding for Memory mapped I/O and I/O mapped I/O. (8) Various types of Interrupts in 8085. (4) Programmable Peripheral Devices and Interfacing with 8085: 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications. (10) 8051 Architecture and Special Function Registers, Organizations and Pin out details, Instruction sets, Special Function Registers, Assembly language programming, Memory Interfacing with 8051, Practical applications. (10) 8086 Microprocessor, Architectures, Organizations and Pin out details, Interrupts, Minimum and Maximum modes of operation, Instruction sets, Assembly language programming. (8)

Text Books, and/or reference material	Text Books: 1. The 8085 Microprocessor: Author: Ramesh Gaonkar, Pub: PRI 2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi& J. G. Mazidi. 3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd. Reference Books: 1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newness, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3.Embedded Systems Design - A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	3	2	1	3	1	1	1	
CO2	3	1	2									1
CO3	3	3	3									1
CO4	3	3	3	3	3	1	1	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

2018 ONWARD UNDERGRADUATE ADMISSION BATCH

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT

Departmental Elective: SIXTH SEMESTER

Subject Code	Subject Name
EEE610	Numerical Analysis
EEE611	Instrumentation
EEE612	Modern Control Systems
EEE613	Special Electrical Machines
EEE614	Signals and Systems
EEE615	Advanced Power Electronics
EEE616	Soft Computing Theory and Applications

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE610</td><td>NUMERICAL ANALYSIS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: To acquire an idea about engineering mathematics and linear algebra
• CO2: To learn the Basic concept of numerical computation
• CO3: To learn about solution techniques for linear and nonlinear equations
• CO4: To understand and learn the numerical solution of ordinary differential equation and integration</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Preliminaries of Computing: Basic Concepts, round-off errors, floating point arithmetic, convergence. (2)
Numerical solution of Nonlinear Equations: Bisection Method, fixed point iteration, Newton’s method, error analysis for iterative methods, computing roots of polynomials. (6)
Interpolation and polynomial approximation: Lagrange polynomial, divided differences, Hermite interpolation. (4)
Numerical Integration and Differentiation: Trapezoidal rule, Gaussian quadrature, Euler - Maclaurian formula. (6)
Applied Linear Algebra: Direct methods for solving linear systems, numerical factorization, eigenvalue problems. (4)
Initial Value Problem (IVP) of Ordinary differential equation (ODE): Euler’s method, Taylor’s method, Classical and higher order Runge-Kutta methods Convergence and stability analysis, Multistep method. (6)
Numerical Linear Algebra: Direct methods, Iterative methods, Jacobi or simultaneous iterations, Gauss - Seidel or Successive iterations. (8)
Approximation Theory: Least - square approximation. (2)
Approximating Eigenvalues: Power method, Householder’s method. (2)
Boundary Value problem for ODE: Shooting methods. (2)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Richard L. Burden and J. Douglas Faires, Numerical Analysis, 9th Edition, Cengage Learning 2. J. Matthews and K. Fink, Numerical Methods Using MATLAB, Prentice Hall, 1999. Reference Books: 1. Introductory Methods of Numerical Analysis - S. S. Satry, 4th Edition, Prentice Hall of India Limited

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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CO2	3	3	2	3	3	2	2	1	1	1	1	1
CO3	3	3	2	3	3	2	2	1	1	1	1	1
CO4	3	3	2	3	3	2	2	1	1	1	1	1

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Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE611	INSTRUMENTATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
ECC331 (ANALOG ELECTRONICS), EEC403 (DIGITAL ELECTRONICS)		CT+MT+EA					
Course Outcomes	• CO 1: Given specifications of different measuring instruments for measurement of particular parameter of some known electrical system, compare and judge to find the most suitable one. • CO2: Given application of electrical engineering for measurement of particular parameter along with specified range and accuracy, choose most suitable measuring instrument with the understanding of individual working principles, also judge to fit the given application. • CO3: For some specific parameter to be measured, along with the given range, resolution, accuracy and output format, choose suitable sensor, design associated signal conditioning and analog/digital processing circuit to meet the desired specification. • CO4: Give multi-parameter control application of electrical engineering design a suitable instrumentation, using PLC, suitable measuring instruments and actuators (including PLC programming). • CO5: Design a suitable Data Acquisition System for some complex electrical system such as. Power system sub-station, motor protection and control etc.						
Topics Covered	Basic Concepts of Measurements, Purpose of Instrumentation, Process Variables, generalized configurations and Functional Descriptions of Measuring Instruments, Generalized Performance Characteristics of Instruments. (4) Principles of Transducers, Functions and General Classification of Transducers. Resistive, Inductive, Capacitive, Piezo-electric, Photo-electric, Thermo-electric, Hall, Magneto						

	strictive etc. (8) Measurement of Process Variables, Pressure, Flow, Temperature, Liquid Level, Strain, Force, Torque, Linear and angular displacement/speed etc. (6) Ultrasonic Instrumentation: Ultrasonic transmitter and receiver properties, propagation through medium and interfaces, application in Non-destructive Testing (NDT), measurement of process variables such as flow, level, thickness etc. (4) Microprocessor based Instrumentations, Different Digital Instrumentation, Digital Measurement of Power Factor, Frequency and Time Period, Counters, Embedded systems, Microprocessor/Microcontrollers, classification, different field of application, design of microcontroller-based measuring instrument (4) Programmable Logic Controller (PLC): Introduction, Application, Physical and functional components, Timers, Counters, Shift Registers, Memory, Ladder Diagram, PLC Programming, Interfacing with sensors and actuators. Advance PLCs, analog input output, HMI, SCADA, Communication protocols, PID control through PLC. (10) Data Acquisition Systems: Objective of a DAS, single channel DAS, Multi-channel DAS, Components used in DAS- Converter Characteristics-Resolution-Non-linearity, settling time, Monotonicity. (6)
Text Books, and/or reference material	Text Books: 1. Transduces and Instrumentation- D.V.S. Murthy Prentice-Hill. 2. Instrumentations: Devices and Systems- C.S.Rangan, G.R. Sarma, V.S.V. Mani. Principles of Industrial Instrumentation - D. Patranabis. Tata Mc. Graw Hill. Reference Books: 1. Instrumentation, Measurement and Analysis, Author: B. C. Nakra, K. K. Chaudhry - 2004. 2. Programmable Logic Controllers, Author: William Bolton, Newness Supervisory Control and Data Acquisition, Author: Stuart A. Boyer International Society of Automation. 3. Doebelin, Ernest O. Measurement system. Tata McGraw-Hill Education, 1968. Webster, John-G., ed. The Measurement, Instrumentation, and Sensors: Handbook. Springer, 1999

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1		2	1	3	1	1	1	
CO2	3	1	2									1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1
CO5	3	3	3	3	3	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

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<table>
<tr><td colspan="10">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE612</td><td>MODERN CONTROL SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEE502 (CONTROL SYSTEMS)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: To understand the states for physical systems
• CO2: To analyses LTI continuous systems with state variable representation
• CO3: To understand the advantages of state variable feedback control
• CO4: To understand optimal control
• CO5: To learn the concept of optimal filtering and state estimation as an essential part of control system design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">State Variable Analysis and Design: Concepts of state, variables and state model state models for linear continuous time systems. (4)
Conversion of state variables models to transfer functions, solutions of state equations, state transition matrix, state transition flow graphs. (4)
Eigenvalues, eigenvectors and stability similarity transformation, decompositions of transfer functions. (4)
Canonical state variable models, controllability, and observability. (4)
Linear State variable Feedback, Observer design. (4)
MATLAB tools and case studies. (6)
Optimal Feedback Control: Parameter optimization and optimal control problems, quadratic performance index, state regulator design, Linear Quadratic Optimal Control, Solving quadratic optimal control problems with MATLAB. (8)
Stochastic Optimal Linear Estimation and Control: Linear Quadratic Guassian Control, Optimal filtering, Estimation, Kalman Bucy filter, Kalman filtering (8)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Digital control and state variable methods- M. Gopal
2. Discrete time control systems- K Ogata
3. Modern Control Engineering- K. Ogata
4. Digital Control of Dynamic systems. G.Franklin, J.Powell, M.L. Workman.
5. Nonlinear Systems - H. K. Khalil
Reference Books:
1. Nonlinear System Analysis - M. Vidyasagar
2. Applied Nonlinear Control - Jean-Jacques E Slotine, Weiping Li</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	1	2	1	2	1	3	3
CO2	3	3	2	3	3	1	2	1	2	1	3	3
CO3	3	3	2	3	3	2	2	1	2	1	3	3
CO4	3	3	2	3	3	2	2	1	2	1	3	3
CO5	3	3	2	3	3	2	2	1	2	1	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE613	SPECIAL ELECTRICAL MACHINES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+MT+EA					
Course Outcomes	• CO 1: Ability to understand the operation of AC Commutator machines and AC Series motor • CO2: To develop clear concept of Universal motor and Repulsion motor • CO3: To analyze and control the operation of Stepper motor • CO4: To analyze the operation of Switched Reluctance motor • CO5: To understand the operation of PM dc motor and Brushless dc motor • CO6: To learn the working of Single-phase synchronous motors						
Topics Covered	AC Commutator machines: Production of different induced emfs, torque equations, characteristics. (3) AC Series motor: Introduction, compensated and uncompensated series motors, emf and torque equations, phasor diagrams, characteristics (3) Universal motor: Operating principle with ac and dc, comparison of speed for dc and ac supplies and characteristics. (3) Repulsion motor: Construction, principle of operation, phasor diagram andcharacteristics. (2) Stepper Motors: Introduction, operating principle, full step, half step, micro step, classification of stepper motors, motor windings, permanent magnet stepper motor, variable reluctance stepper motor, hybrid stepper motor, energization with 2-phases at a time, single-phase stepper motor, mathematical analysis of stepper motor, open loop control of 2- phase stepper motor, open loop control of 3-phase VR stepper motor, closed loop control of a stepper motor, slew speed, ramping, applications. (8) High speed operation of stepper motor: Introduction, Pull-out torque-speed characteristics for hybrid stepper motor, Pull-out torque-speed characteristics for variable reluctance stepper motor. (4) Switched Reluctance motor: Introduction; principle of operation; differences between SR and conventional reluctance motor, Torque expression, characteristics, control, advantages and disadvantages. (5) Permanent magnet materials and motors: Introduction; minor hysteresis loops and recoil line; stator frames of conventional PM dc motors; Equivalent circuit of a permanent magnet. (5) Brushless dc motor: Types of construction, principle of operation, modeling, motor characteristics and control, advantages and disadvantages. (5) Single-phase synchronous motors: Single-phase reluctance motor, hysteresis motor, Linear Induction motor. (4)							

Text Books, and/or reference material	Text Books: 1. Special Electrical Machines: K. Venkataratnam, Universities Press. 2. Stepping Motors and Their Microprocessor Controls: T. Kenjo, Clarendon Press. Reference Books: 1. Permanent Magnet and Brushless DC Motors: T. Kenjo and S. Nagamori, Oxford University Press. 2. Electric Machinery Fundamentals: Stephen J. Chapman,McGraw-Hill Education.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3	2	3	1			2	
CO2	3	2	2	1	2	2	3	1			1	
CO3	3	2	2	1	3	2	3	1			2	
CO4	3	2	2	1	3	2	3	1			2	
CO5	3	2	2	1	3	2	3	1			2	
CO6	3	2	2	1	3	2	3	1			2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE614	SIGNALS AND SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO 1: To understand the properties continuous and discrete signals and systems, sampling process. • CO2: To analyze LTI discrete time systems in time domain. • CO3: To understand and frequency response of continuous and discrete time signals and system. • CO4: To learn time frequency characterization of signal and systems • CO5: To get the knowledge of communication systems • CO6: To understand the concept of linear feedback system.
Topics Covered	Introduction: Signals, systems and sampling (2) Discrete-time Signals and Systems: Discrete time signals and systems, Analysis of LTI system, system described differential and difference equation (4) Fourier Series Representation of Periodic Signals and Filtering (4) Frequency Domain Analysis: Frequency analysis of continuous-time and discrete-time signals and LTI systems, Continuous time Fourier Transform (6) Discrete Fourier Transform: Properties and Applications, Analysis using DFT (4) Fast Fourier Transform Algorithms: FFT algorithms and Applications, linear filtering approach to computation of DFT (6) Time and Frequency characterization of Signals and Systems: The magnitude and phase

	representation of Frequency Response of LTI systems (6) Communication systems: Sinusoidal Amplitude Modulation, Demodulation sinusoidal AM, Discrete time Modulation (4) The Z-transform: Review, Analysis of LTI system in z-domain. (4) Feedback LTI Systems. (2)
Text Books, and/or reference material	Text Books: 1. Signals and Systems, A. V. Oppenheim, Alan A. Willsky and S. Hamid 2. Signals, Systems and Inference, A. V. Oppenheim, G. C. Varghese Reference Books: 1. Linear Signals and Systems, B. P. Lathi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	1	1	2	1	1	1	1	1
CO2	3	3	2	3	1	2	2	1	1	1	1	1
CO3	3	3	2	3	1	1	2	1	1	1	1	1
CO4	3	3	2	3	1	1	2	1	1	1	1	1
CO5	3	3	2	3	1	1	2	1	1	1	1	1
CO6	3	3	2	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE615	ADVANCED POWER ELECTRONICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC 504 (POWER ELECTRONICS), EEC 502 (CONTROL SYSTEMS)		CT+MT+EA					
Course Outcomes	• CO1: To review of basic Power Electronic Systems • CO2: To learn the operation of isolated and non-isolated type Switch-Mode DC-DC Converters • CO3: To understand the concept of Multilevel Converters and modulation techniques • CO4: To understand converter dynamics and control, modelling techniques. • CO5: To familiarize with different Gate and Base Drive circuits for Power Devices • CO6: To get acquainted with the state-of-the-art applications of power electronics in Industry and utility systems						
Topics Covered	Review of Power Electronic Systems. Overview of Some Modern Power Semiconductor Devices. (2) Switch-Mode DC-DC Converters: Introduction, Control of DC-DC converters, Buck, Boost, Buck-Boost, Full bridge Converter. (4) Isolated Switching DC Power Supplies: Comparison between Linear & Switching Power						

	Supply, Specification of SMPS, Different Topologies, Flyback, Forward, Push-Pull, Half and Full Bridge), Control Requirements & Techniques, Practical SMPS Design Consideration. (4) Multilevel Converters: Introduction, different topologies, Neutral Point Clamped (NPC), Flying Capacitor Converter, Cascaded Multilevel Converters. (4) Different PWM techniques for Inverters: Space Vector PWM technique, Carrier Based Modulation technique. (4) Converter Dynamics and Control: State Space Averaging, Converter transfer function, concept of controller design. (4) Gate and Base Drive circuits for Power Devices: Concept, different circuits applicable to converters. (2) Applications: DC Drives, AC Drives, Power Conditioners and Uninterruptible Power Supplies, Power Line Disturbances, Power Conditioners, UPS. (6) Other Residential and Industrial Applications: Electronic ballast, Induction Heating, Electrical Welding, Static Circuit Breakers, Solid State Relays, HVDC Transmission, Static Var Compensators. Integration of Renewable Energy in Electric Power Systems. (12)
Text Books, and/or reference material	Text Books: 1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2. H. W. Whittington, Switch Mode Power Supplies: Design and Construction, Research Studies Press. 3. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1. R. W. Erickson and D. Maksimovic, Fundamental of Power Electronics, Springer 2. E. Acha, V. G. Agelidis, O. Anaya-Lara and T. J. E. Miller, Power Electronic Control in Electrical Systems, Newnes 3. L. Umanand, Power Electronics, Essential and Applications,Wiley India Pvt. Ltd.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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CO3	3	3	3	3	3	3	3	2	2	1	2	2
CO4	3	3	3	3	3	3	3	2	2	1	2	2
CO5	3	3	3	3	3	3	3	2	2	1	2	2
CO6	3	3	3	3	3	3	3	2	2	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE616</td><td>SOFT COMPUTING THEORY AND APPLICATION</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEE610 (NUMERICAL ANALYSIS)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: For the given linear and non-linear problems under practical limitations, compare classical analytical method and soft computing technique.
• CO2: For a given single objective problem (SOP), apply binary coded genetic algorithm (BCGA) and real coded genetic algorithm (RCGA) with different types of crossover, mutation and also understand the impact of different parent selection strategies.
• CO3: For a given non-linear or non-derivative problem, tune the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation.
• CO4: For a given multi-objective problem, explain the significance of Difference vector in Differential Evolutionary (DE) technique and also illustrate self-adaptive differential evolutionary (SADE) technique.
• CO5: For a given problem, logically clarify the impact of hidden layers in artificial neuron network (ANN) and also stepwise explicate the back-propagation algorithm of ANN.
• CO6: For a given problem, describe fuzzy knowledge base controller (FKBC) showing information and computational flow with membership function, rule base and defuzzification.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to soft-computing techniques and its necessity. (1)
Fundamentals of genetic algorithm, Genetic algorithm, Encoding, Fitness function, Reproduction, Genetic modelling, Cross Over, Inversion and Deletion, Mutation operator, Bit-wise operators, examples. (7)
Basic Steps in Particle Swarm Optimization algorithm, Bird flocking & fish schooling, velocity, inertia weight factor, pbest solution, gbest solution, local optima, global optima, examples, new modifications of PSO, Parameter Selection in PSO; (7)
Fundamentals of Differential Evolution algorithm, difference vector and its significance, Mutation and crossover, comparisons among DE, PSO and GA, Examples, new modifications of DE, Improved DE schemes for noisy optimization problems. (8)
Fuzzy set theory, Fuzzy systems, crisp sets and fuzzy sets, fuzzy set operations and approximate reasoning, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, examples. (8)
Biological neural networks, Model of an artificial neuron, neural network architecture, Characteristics of neural network, learning methods, Taxonomy of neural network architecture, Back propagation networks, architecture of a back propagation network, back propagation learning, Examples, RBF network, Associative memory, Adaptive resonance theory. (9)
Applications of Soft Computing to various fields of engineering. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Devendra K. Chaturvedi, “Soft Computing- techniques and its application in electrical engineering”, Springer, 2008.
2. Carlos A. Coello,Garry B. Lamont, David A. van Veldhuizen, “Evolutionary Algorithms</td></tr>
</table>

	for solving Multi-objective Problems", Second Edition, Springer, 2007. Reference Books: 1. Jyh-Shing Roger Jang, Chuen-Tsai Sun &Eiji Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall 2. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and genetic Algorithm Synthesis and Applications, PHI 3. L. A. Zadeh, Fuzzy Sets and Applications, John Wiley & Sons

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	1	2	2	2	1
CO2	3	3	2	2	3	1	1	1	2	3	2	1
CO3	3	2	2	1	2	1	1	1	2	3	2	1
CO4	3	2	2	1	2	1	1	1	2	3	2	1
CO5	3	2	2	1	2	1	1	1	2	3	2	1
CO6	3	2	2	2	2	2	1	2	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES651	ELECTRICAL MACHINES LABORATORY - II	PCR	0	0	3	3	1.5
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
EES553 (ELECTRICAL MACHINES LABORATORY - I), EEC402 (ELECTRICAL MACHINES-I), EEC504 (ELECTRICAL MACHINES-II)			CT+EA				
Course Outcomes	• CO1: Ability to determine the equivalent circuit parameters of a single-phase Induction Motor and also a three-phase Induction Motor. • CO2: Ability to calculate the parameters of a synchronous machine and evaluate the voltage regulation of an alternator • CO3: Ability to synchronize two three-phase alternators and to observe sharing of loads between them • CO4: Ability to obtain the V-curves of a synchronous motor • CO5: Ability to determine the efficiency of dc machines • CO6: Ability to determine the efficiency and temperature rise of a transformer						
Topics Covered	List of Experiments: 1. To perform no-load and blocked-rotor tests on a single-phase Induction Motor. 2. To perform no-load and blocked-rotor tests on a three-phase Induction Motor. 3. Voltage regulation of an alternator. 4. Parallel operation of two three-phase alternators.						

	5. To determine the V-curves of a synchronous motor. 6. Determination parameters of a salient pole synchronous machine. 7. Hopkinson's test on dc shunt machines 8. The Sumpner's test of transformer 9. Determination of positive, negative and zero sequence impedances of a synchronous machine
Text Books, and/or reference material	Text Books: 1. A. S. Langsford, Theory of A. C. Machines, Tata McGraw Hill. 2. I. L. Kosow, Electric Machinery & Transformers, PHI Reference Books: 1. Laboratory manuals

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	2	1	1	1	2	2	2	2
CO2	3	2	2	2	3	2	1	1	2	2	1	1
CO3	3	2	3	2	1	1	1	1	2	2	1	1
CO4	3	2	2	2	2	1	1	2	2	2	1	1
CO5	3	2	2	2	2	1	1	1	2	2	1	1
CO6	3	2	2	2	1	1	1	1	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES652	POWER ELECTRONICS LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
EES553 (ELECTRICAL MACHINES LAB -II, EEC402 (ELECTRICAL MACHINES-I), EEC501 (ELECTRICAL MACHINES-II)	CT+EA

Course Outcomes	• CO1: To understand the principal of power electronics devices • CO2: To understand the detail operation of the ac-dc/ dc-dc/ ac-ac/ dc-an components • CO3: To understand the implementation of the components for dc and ac machine control. • CO4: To develop the ability to design and implement different converters and gate driver circuits • CO5: To understand the control of the converters
Topics Covered	List of Experiments: 1. Microprocessor Based Single Phase Firing Circuit (a) To study half wave converter circuit using Microprocessor (b) To study AC voltage regulator circuit using Microprocessor 2. Single Phase Bridge Inverter Using IGBT 3. Three Phase SCR Module

	(a) Three Phase Half Controlled Bridge Rectifier with R and R-L load (b) Three Phase Fully Controlled Bridge Rectifier R and R-L load (c) Three Phase AC Voltage Controller with R and R-L load 4. Speed Control of 30 AC Induction Motor Using IPM and MICRO-2407 (a) Open Loop Control of Three Phase Induction Motor by using V/F control (b) Closed Loop Control of Three Phase Induction Motor by using V/F control. 5. Speed Control of DC Motor by Using Single Phase Triggering and Device module 6. Four Quadrant Operation of DC-DC Chopper 7. Simulation of Gate Driver Circuits of Power Converters by Using PSpice 8. Simulation of Basic DC-DC Converters by Using Multisim 9. Modelling and control of Buck and Boost Converter by Using MATLAB Closed Loop Control of Boost Converter by Using Multisim
Text Books, and/or reference material	Text Books: 1.N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2. JosephVithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1. Laboratory Manuals

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	1	3	1	3	3
CO2	3	3	3	3	3	3	3	1	3	1	3	3
CO3	3	3	3	3	3	3	3	1	3	1	3	3
CO4	3	3	3	3	3	3	3	1	3	1	3	3
CO5	3	3	3	3	3	3	3	1	3	1	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES653	POWER SYSTEMS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC401 (POWERSY STEMS-I) EEC503(POWER SYSTEMS- II)		CT+EA					
Course Outcomes	• CO 1: Understand various types of relay implementation using static circuits. • CO2: Realization of characteristics for over current, distance and differential relays using test bench. • CO3: Realize the various dynamic characteristics of digital relays for protection of transmission lines, transformers. • CO4: Identify the new developments in protective relaying and applications						

Topics Covered	List of Experiments: The Power system Laboratory includes the protection schemes and simulation related experiments. Facilities are available for over current, over voltage, directional, differential and distance relays including different numerical relays, Feeder Protection. Varieties of Power system Simulation packages like Load flow using MATLAB, EUROSTAG and MiPower are available. List of experiments: 1. Study of Inverse Definite Minimum Time over-current relay. 2. Study of Directional over-current relay (inverse) type CDD. 3. Study of Numerical Distance protection Relay MiCOM P442. 4. Parallel Feeder Protection. 5. Negative sequence protection of three-phase induction motor. 6. Study of over-voltage relay. 7. Study of Biased Differential Relay 8. Biased Differential Protection of a single-phase Transformer 9. Restricted E/F Protection of 3-phase Transformer 10. Over-current and Earth fault protection scheme for three phase system. 11. To study load flow and different dynamic events of the given network using EUROSTAG / Mi Power software 12. Study of Cable Fault Locator.
Text Books, and/or reference material	Laboratory Manuals

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	1	2	2	2
CO2	3	3	3	3	3	2	1	1	1	2	2	3
CO3	3	3	3	3	3	3	2	2	2	2	2	3
CO4	3	3	3	3	3	2	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

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Semester - VII						
Code	**Subject**	**L**	**T**	**S**	**C**	**H**
MSC731	**Principles of Management**	**3**	**0**	**0**	**3.0**	**3**
EEE710 --	**Depth Elective - 3**	**3**	**0**	**0**	**3.0**	**3**
EEE710 --	**Depth Elective - 4**	**3**	**0**	**0**	**3.0**	**3**
EEE710 --	**Depth Elective - 5**	**3**	**0**	**0**	**3.0**	**3**
YYO74*	**Open Elective - 3**	**3**	**0**	**0**	**3.0**	**3**
EES751	**Microprocessor and Microcontroller Laboratory**	**0**	**0**	**3**	**1.5**	**3**
EES752	**Advanced Power System Laboratory**	**0**	**0**	**3**	**1.5**	**3**
EES753	**Electrical machine Design Laboratory**	**0**	**0**	**3**	**1.5**	**3**
EES754	**Vocational Training / Summer Internship and Seminar**	**0**	**0**	**2**	**1.0**	**2**
EES755	**Project - I**	**0**	**0**	**3**	**1.0**	**3**
	TOTAL	**15**	**0**	**14**	**21.5**	**29**

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	**PRINCIPLES OF MANAGEMENT**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes

- CO1: To make budding engineers aware of various management functions required for any organization
- CO2: To impart knowledge on various tools and techniques applied by the executives of an organization
- CO3: To make potential engineers aware of managerial function so that it would help for their professional career
- CO4: To impart knowledge on organizational activities operational and strategic both in nature
- C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science

Topics Covered

UNIT I: Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter's five forces, Management functions – overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization **(8)**

UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique **(7)**

UNIT III: Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. **(8)**

UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. **(8)**

UNIT V: Finance and Accounting: Basics of Financial management of an organization,

	Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. **(12)**
Text Books, and/or reference material	Text Books: 1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. 2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 3. Management Principles, Processes, and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education 4. Organizational Behavior,13 th edition, Stephen P Robbins,Pearson Prentice Hall India 5. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey

Course Code	Course Title	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MSC731	Principles of Management	CO1									3	2	2	
		CO2				2					2	2		
		CO3				2					3	2		
		CO4							1		3			
		CO5				2					2	2	2	

2018 ONWARD UNDERGRADUATE ADMISSION BATCH

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT

Departmental Elective: SEVENTH SEMESTER

Subject Code	Subject Name
EEE710	Renewable Energy Systems
EEE711	Advanced Power Converters
EEE712	Generalized Theory of Electrical Machines
EEE713	Electrical Drives
EEE714	Power System Planning, Operation and Control
EEE715	Embedded Systems
EEE716	FACTS Device
EEE717	Generation & Utilization of Electrical Power
EEE718	Advanced Control Systems
EEE719	Microprocessor & Embedded Systems
EEE720	Digital Signal Processing
EEE721	Design of Flight Control Law
EEE722	Power system restructuring & deregulation

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE710</td><td colspan="2">RENEWABLE ENERGY SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td colspan="2">3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="7">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="8">• CO1: To understand the basics of Energy System and overall energy resources
• CO2: To design the solar and wind power plant
• CO3: To understand the tidal, geothermal energy, biomass and other resources and principles
• CO4: To understand the energy conservation opportunities and energy saving</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="8">Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification, relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission. (9)
Solar photovoltaic: Introduction, solar radiation & its relationship with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors: -materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments. (8)
Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. (6)
Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. (4)
Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects. (5)
Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid. (5)
Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics. (5)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="8">Text Books:
1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003.
2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press.
3. Fuel Cell Handbook, Parsons Inc.
4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1		1	1	1			1	1
CO2	3	3	2	1	1	1	1				1	1
CO3	2	3	3	2	1	1	1	1	1		1	1
CO4	2	3	3	2		1	1	1	1		2	1

Correlation levels 1, 2 or 3 as defined below:

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<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE711</td><td>ADVANCED POWER CONVERTERS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC504(POWER ELECTRONICS), EEC502(CONTROL SYSTEMS)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: To get an overview of Power Electronic Converters.
• CO2: To learn the operation of Switch-Mode DC-DC Converters and some advanced converters.
• CO3: To understand the concept of Switch Mode DC-AC Inverters, Multilevel Inverters& modulation techniques.
• CO4: To familiarize with EMI & EMC issues in power electronic systems.
• CO5: To get acquainted with design of power electronic systems
• CO6: To get acquainted with practical applications, simulation, and hands on training of power electronic converters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overview of basic power electronics converters. (2)
Switch-Mode DC-DC Converters: Introduction, Control of DC-DC converters, Buck,Boost, Buck-Boost, Cuk, Full bridge Converter, and Some advanced converters: Tristate, Interleaved, Multiphase & Higher order converters. (8)
Switch Mode DC-AC Inverters: Single Phase & Three-Phase Inverters, PWM switching schemes, space vector modulation, reduction of harmonics, output voltage control, Multilevel Inverters. (8)
AC voltage controllers: Single phase and three phase ac voltage controllers, Voltage control, Harmonic analysis, operation waveforms PWM, Matrix converters. (6)
Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) Issues: EMI reduction At Source, EMI Filters, EMI Screening, EMI Measurement and Specifications. (4)
Design considerations: snubber circuit, driver circuit, temperature control and heat sink, materials, windings. Design of converter and chopper circuits. Triggering circuits for converter and choppers. MMF equations, magnetic. Design of transformers and inductors. (8)
Some practical applications, literature study, simulation, and hands on training of power electronic converters. (6)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2. H. W. Whittington, Switch Mode Power Supplies: Design and Construction, Research Studies Press. 3. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1. R. W. Erickson and D. Maksimovic, Fundamental of Power Electronics, Springer 2. E. Acha, V. G. Agelidis, O. Anaya-Lara and T. J. E. Miller, Power Electronic Control in Electrical Systems, Newnes 3. L. Umanand, Power Electronics, Essential and Applications,Wiley India Pvt. Ltd.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	2	2	2	1	3
CO2	3	3	3	3	3	3	3	2	2	1	2	2
CO3	3	3	3	3	3	3	3	2	2	1	2	2
CO4	3	3	3	3	3	3	3	2	2	1	2	2
CO5	3	3	3	3	3	3	3	2	2	1	2	2
CO6	3	3	3	3	3	3	3	2	2	2	3	3

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Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE712	GENERALIZED THEORY OF ELECTRICAL MACHINES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC402 (ELECTRICAL MACHINES-1), EEC501 (ELECTRICAL MACHINES- II)		CT+MT+EA					
Course Outcomes	• CO 1: To understand the basic concept of Generalized theory of Electrical machines • CO2: To learn about Reference Frame theory • CO3: To transform 3-phase quantities to 2-phase quantities and vice-versa. • CO4: To model a 3-phase induction machine • CO5: To model a 3-phase synchronous machine • CO6: To perform both steady-state and transient analysis of DC machines						
Topics Covered	Generalized Machines:Kron's primitive machine, Voltage, power and torque equations of Kron's primitive machine, Basic two-pole machine diagrams. (6) Reference Frame theory: Commonly used reference frames, Equations of transformation, 3- axis to 2-axis transformation, Park's transformation, Clarke's transformation. (4) Theory of symmetrical Induction machines:Dynamic modeling of three-phase induction						

	machine, generalized model of three-phase induction machine in arbitrary reference frame, derivation of induction machine model in stator, rotor and synchronously rotating reference frames from the arbitrary reference frame model, Space-phasor model of induction machine, Normalized model of induction machine, Dynamic performance during sudden change in load torque. (12) Synchronous Machines:Stator and rotor flux linkages, Voltage and torque equations in machine variables, mathematical modeling of synchronous machine, Swing equation, and state- space representation of Swing equation. (8) DC machines:DC generator: Steady-state analysis, transient analysis under different conditions. (6) DC motor: Steady-state analysis, transient analysis under different conditions. (6)
Text Books, and/or reference material	Text Books: 1. Analysis of Electrical Machinery: P. C. Krause, McGraw-Hill. 2. Electric Motor Drives, Modelling Analysis and Control: R. Krishnan, Prentice-Hall Of India Pvt. Limited. Reference Books: 1. Modern Power Electronics and AC Drives: B. K. Bose, Prentice Hall. 2. Generalized Theory of Electrical Machines: P. S. Bimbhra, Khanna Publisher.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	1	1	1	1	1	1	1
CO2	2	3	3	3	3	2	1	1	1	1	2	2
CO3	3	3	3	3	3	3	1	1	1	1	2	2
CO4	3	3	3	3	3	2	1	1	1	1	2	2
CO5	3	3	3	3	3	2	1	1	1	1	2	2
CO6	3	3	3	3	3	3	1	1	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE 713	ELECTRICAL DRIVES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC402 (ELECTRICAL MACHINES-1), EEC504 (POWER ELECTRONICS), EEC502 (CONTROL SYSTEMS), EEC 501 (ELECTRICAL MACHINES-II)		CT+MT+EA					

Course Outcomes	• CO 1: Acquire an idea general drives application in Industry • CO2: To learn the detailoperation of the dc drives • CO3: To learn the detailoperation of the ac drives • CO4: To identify the drives and machine combinations for any particular application • CO5: To develop a clear idea about the dynamic performance of the drives

Topics Covered	DC drives: Braking of dc motors, speed control of dc motors, Single-phase half and full-controlled rectifier control of separately excited dc motor, three phase half and full-controlled and half controlled rectifier control of separately excited dc motor, chopper-controlled dc drives, closed loop control of dc drives. (12) AC drives: Braking of ac motors, speed control of ac motors, basic inverters circuits, variable voltage frequency control, VSI fed induction motor drives, AC voltage controller, cycloconverter, closed loop control of induction motor drives. (12) Heating and selection of power rating of drive motors: Heating and temperature rise of motors, selection of motor power capacity, equivalent current, torque and power methods. (6) Transients and Dynamics: Equation of motion, equivalent system, dynamics during dynamic braking of dc shunt motor, speed, time of braking and current during dynamic braking, dynamics during counter current braking of dc shunt motor, energy associated with transient process of dc shunt motor, dynamic response of induction motor, dynamics during starting and braking of induction motor. (8) Industrial application of motors: Cement mill, paper mill, textile mills etc. (4)
Text Books, and/or reference material	Text Books: 1. G. K. Dubey, Fundamentals of Electrical Drives, Narosha Publishing House, 2001. 2. N. K. De and P. K. Sen, Electric Drives, PHI, 2001. Reference Books: 1. V. Subrahmanyam, Electric Drives, Tata McGraw Hill. 2. S. K. Pillai, A first course in electrical drives, New Age international, 1989.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	1	1	1	1	2	2
CO3	3	3	3	3	3	2	1	1	1	1	2	2
CO4	3	3	3	3	2	3	1	1	1	1	1	2
CO5	3	3	3	3	3	2	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE714	POWER SYSTEM PLANNING, OPERATION AND CONTROL	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC 401 (POWER SYSTEM-I), EEC 503 (POWER SYSTEM-II)		CT+MT+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Analyse the performance of interconnected power systems by performing power flow analysis.						

	• CO2: Perform operation scheduling of different power plants (Hydro and Thermal) for both stable and economic operation. • CO3: Model different power system equipment like governor, turbine, transmission line, generator, load and perform regulation of active, reactive power and frequency of the system by designing suitable controllers. • CO4: Estimate the size and type of power factor correcting device required for optimal as well as stable economic operation of power system. • CO5: understand cause, effect as well as control of different types of overvoltage conditions that arise in a power system. • CO6: understand different types of tariffs normally applicable for power system operation.
Topics Covered	Load flow studies: Network model formulation, formation of Ybus, load flow problem, Gauss-Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods. Advantages and disadvantages. (8) Tariffs: Introduction, Types of Tariff-Flat demand tariff, straight line meter rate tariff, Block meter type tariff, Two-part tariff, Power factor tariff, Peak load tariff, three-part tariff (2) Economic operation of power system: Incremental fuel cost, economic dispatch neglecting transmission losses, transmission loss as a function of plant generation, General loss formula, Optimum load dispatch considering transmission losses. (5) Optimal Hydrothermal Scheduling: Classification of hydro plants, long range problem, short range problem, hydro model, equality and inequality constraints, transmission losses. (5) Unit commitment: Definition, constraints in unit commitment, Methods available for unit commitment (priority list method & Dynamic programming). (4) Load frequency control: Necessity of keeping frequency constant, load frequency of single area, load frequency of single area model of speed governing system, load frequency control of two area system, block diagram representation of an isolated power system, steady state analysis, dynamic analysis, uncontrolled system, uncontrolled system, proportional plus integral control of single area and its block diagram, steady state response (proportional plus integral control), dynamic response (proportional plus integral control). (5) Automatic Generation Control: Types of alternator exciters, exciter modelling, modelling of alternator, static and dynamic performances of AVR, compensation in AVR loop. (4) Power Factor Improvement: Introduction, Disadvantages of low power factor, causes of low power factor, power factor improvement, power factor correction by static capacitor. Economics of power factor improvement. (5) Protection against over voltages: voltage surge, causes of over voltages, Internal causes of over voltages, lightning, protection against lightning, earthing screen, overhead ground wire, lightning arrester, surge absorber. (4)
Text Books, and/or reference material	Suggested Text Books: 1. P. M. Anderson & A. A. Fouad, Power system control and stability, Wiley Inter science 2. E.W. Kimbark, Power Systems Stability, Vol. I, II & III, Wiley Press Reference Books: Suggested Reference Books: 1. D.P. Kothari & I.J. Nagrath, Modern Power System Analysis, Tata Mc-Graw Hill 2. Subir Ray, Electrical Power Systems, PHI. 3. HadiSadaat, Power System Analysis, Tata Mc-Graw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	3	2	2	0	0	1	1	1
CO2	2	3	2	2	2	3	2	0	0	1	1	1
CO3	2	3	3	2	3	2	2	0	0	1	1	1
CO4	3	3	2	2	2	2	1	0	0	1	0	1
CO5	1	2	2	2	1	1	1	0	0	1	0	0
CO6	1	2	2	2	1	1	0	0	0	0	0	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE715	EMBEDDED SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC602(MICROPROCESSOR & MICROCONTROLLER)		CT+MT+EA					
Course Outcomes	• CO1: Comparing different microprocessor architectures and justifying their field of application. • CO2: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application. • CO3: Programming processor specific and processor independent software for different complex embedded system applications. • CO4: Developing software involving Real Time Operating System. • CO5: Knowledge of advanced microcontrollers and RTOS features.						
Topics Covered	Introduction to Embedded systems: Introduction - Features - Microprocessors - ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP CISC and RISC - Instruction pipelining. General characteristics of embedded system, introduction to different components etc. (8) Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports.(7) Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features.(8) ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc. (7) Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (7) Basic design using a real time operating system: Overview. General principles. Design of an embedded system. Development Tool: Cross-Compiler, Cross-Assemblers, Linker/locator. PROM Programmers, ROM, Emulator, In-Circuit Emulators. Debugging						

	Techniques. Instruction set simulators. The assert macro. (5)
Text Books, and/or reference material	Text Books: 1. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. 2. An Embedded Software Primer, D.E. Simon. Pearson Education, 1999. 3. Design with PIC Microcontrollers, J.B. Peatman,Pearson Education, 1998 Reference Books: 1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1		2	1	3	1	1	1	
CO2	3	1	2	1	1			1				1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1
CO5	3	3	3	1								1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE716	FACTS DEVICE	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC401(POWERSYSTEMS-I), EEC504(POWER ELECTRONICS), EEC503(POWER SYSTEMS– II)		CT+MT+EA					
Course Outcomes	• CO 1: Understand the basic concept of FACTS devices. • CO2: Acquire knowledge about working principles of FACTS devices and their operating characteristics of FACTS devices. • CO3: Acquire an idea about modelling of various FACTS devices and their interaction in power system. • CO4: Understand how FACTS devices improve various power system performances like power flow control, stability etc.						
Topics Covered	Introduction: Basics of Power Transmission Networks, Control of Power Flow in AC Transmission Line, Flexible AC Transmission, System Controllers, Concept and General System of Considerations, Checklist of possible benefits from FACTS technology, Application of FACTS Controllers in Distribution Systems. (2) Traditional Compensation: Analysis of Uncompensated AC Line, Passive Reactive Power Compensation, Compensation by a Series Capacitor Connected at the Mid-point of the						

	Line, Shunt Compensation Connected at the Midpoint of the Line, Basics of Phase Shifting, Effects and Applications of different Compensators. (6) Static Var Compensator (SVC): Analysis of SVC, Configuration of SVC, Variable Impedance Type Static Var Generators, TCR, TSR, TSC, FC-TCR.SVC Controller, Harmonics and Filtering, Modeling and applications of SVC. (6) Static Synchronous Compensator (STATCOM): Switching Converter Type Var Generators, Basic concept and Principle of Operation of STATCOM, Basic converter configurations, Control of converters, modeling and applications of STATCOM. (5) Static Series Compensators: Basic Concepts of Controlled Series Compensation, Operation of TCSC, Analysis of TCSC, Control of TCSC, Modeling of TCSC for Stability Studies, Mitigation of Sub-synchronous, Applications of TCSC. (6) Static Synchronous Series Compensator: Operation of SSSC and the Control of Power Flow, Modeling and Control of SSSC, SSSC with an Energy Source, Analysis of SSR with a SSSC, Applications of SSSC. (5) Static Phase Shifting: Basic Principle of a PST, Configurations of SPST, Improvement ofTransient Stability Using SPST, Damping of Low Frequency Power Oscillations, Applications of SPST. (5) Combined Compensators:Unified Power Flow Controller (UPFC), Basic operating principles, Conventional transmission control capabilities, Functional control of shunt converter and series converter, Basic control systems for P and Q control, Interline Power Flow Controller. (7)
Text Books, and/or reference material	Text Books: 1. Yong Hua Song and Allan T Johns, “Flexible ac transmission systems (FACTS), the Institution of Electrical Engineers (UK), 2002. 2. N. G. Higorani& L. Gyugui, “Understanding FACTS”, IEEE press, Standard Publishers Distributor, Delhi Reference Books: 1. K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New age International (P) Ltd. 2008 2. R. Mohan Mathur and Rajiv K. Varma, “Thyristor-Based FACTS Controllers for Electrical Transmission Systems”, IEEE Press, John Wiley & Sons, 2002

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	2	3	2	1
CO2	3	3	3	2	3	1	1	1	2	3	2	1
CO3	3	2	2	1	2	1	1	1	2	3	2	1
CO4	3	2	2	2	2	1	1	2	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE717</td><td>GENERATION & UTILIZATIONOF ELECTRICAL POWER</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: understand electrical power generation by thermal, hydro and nuclear power plant
• CO2: understand the principle of operation of different types of lamps and selection of lamps for different applications.
• CO3: understand different electric traction systems.
• CO4: understand different heating methods and their applications.
• CO5: create awareness of electrical energy conservation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Generation: Importance of electrical energy; Generation of electrical energy by conventional methods; Thermal power plant - merits and demerits, selection of site, layout and working of the plant, components of the plant; Hydro power plant - merits and demerits, selection of site, layout and working principle, classification of the plant, Elements of the plant - water turbines, generator, etc.; Nuclear power plant - merits and demerits, selection of site, nuclear fission process, constituents of the plant, layout and working of the plant, nuclear reactor (15)
Illumination: Nature of light; Concept of illumination, luminous intensity, and luminance; polar curve, M.H.C.P., M.S.C.P, M.H.S.C.P; laws of illumination; photometer; Sources of light; Types of lighting scheme; Design of indoor and outdoor lighting system. (8)
Electric Traction: Traction system; Duty cycle of traction drives; Calculations of traction drive ratings and energy consumption; Systems of track electrification; Traction motors; DC and AC traction drives. (8)
Electric Heating: Advantages of electric heating; Classification of electric heating; Resistance heating; Electric arc furnace, Induction heating; Dielectric heating. (6)
Economics Aspect of Power: Generation cost; Interest and depreciation; Load curve andchoice of generating stations, Tariff; Economics of power factor improvement plant. (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. C. L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New Age International (P) Limited.
Reference Books:
1. S. C. Tripathy, Electric Energy Utilisation and Conservation, Tata McGraw Hill.
2. N.V. Suryanarayana, Utilisation of Electric Power, Wiley Eastern Ltd.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	2	2	1	1	1	2	1
CO2	3	3	3	3	2	3	2	2	2	1	2	2

CO3	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**1**
CO4	**3**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**2**	**1**
CO5	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**1**	**1**	**1**	**2**

Correlation levels 1, 2 or 3 as defined below:

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Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE718	ADVANCED CONTROL SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEE502 (CONTROL SYSTEMS)		CT+MT+EA					
Course Outcomes	• CO 1: To understand discrete systems, sampling and hold process • CO2: To analyse LTI discrete systems in time domain • CO3: To understand the concept of stability in discrete time, correlation with s-plane • CO4 To learn the frequency domain analysis of discrete systems • CO5: To design controller system for digital control implementation • CO6: To understand nonlinear systems and to determine its stability • CO7: To design controller for nonlinear systems						
Topics Covered	Design of control systems by classical methods: Practical approaches of control system design, some practical Problems, hardware realization, Use of MATLAB in design practice (6) Sampled Data Control Systems: The sampling process, signal reconstruction, difference equations, Z-transform theory, Z-transfer functions (pulse transfer functions), inverse Z-transform and response of linear discrete systems, Z-transform analysis of sampled data control systems, Z and S domain relationship stability analysis in Z-plane (12) Root Locus analysis, Frequency domain Analysis of sampled data system, Compensator design, State space analysis of sampled data systems, MATLAB based Examples. (12) Non-linear Control Systems: Introduction, Classification of Non-linearities, Phenomena exhibited due to presence of non-linear element in control system, Phase plane analysis, singular points, Describing function method of analysis, Lyapunov Stability, Region of Attraction. (12)						
Text Books, and/or reference material	Text Books: 1. Digital control and state variable methods- M. Gopal 2. Discrete time control systems- K Ogata 3. Modern Control Engineering- K. Ogata 4. Digital Control of Dynamic systems. G.Franklin, J.Powell, M.L. Workman. 5. Nonlinear Systems - H. K. Khalil Reference Books: 1. Nonlinear System Analysis - M. Vidyasagar 2. Applied Nonlinear Control - Jean-Jacques E Slotine, Weiping Li						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	1	1	2	1	1	1	1	1
CO2	3	3	2	3	1	1	2	1	1	1	1	1
CO3	3	3	2	3	1	1	2	1	1	1	1	1
CO4	3	3	2	3	1	1	2	1	1	1	1	1
CO5	3	3	2	3	3	2	2	1	1	1	1	1
CO6	3	3	2	3	1	1	2	1	1	1	1	1
CO7	3	3	2	3	3	2	2	1	1	1	1	1

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE719</td><td>MICROPROCESSOR AND EMBEDDED SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC403 (DIGITAL ELECTRONICS)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller.
• CO2: Identify—and exercise—opportunities for hardware and software trade-offs.
• CO3: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor-based system.
• CO4: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application.
• CO5: Programming processor specific and processor independent software for different complex embedded system applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Embedded systems: Introduction - Features - Microprocessors - ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP. CISC and RISC - Instruction pipelining. General characteristics of embedded system, introduction to different components etc. (5)
8085 Architectures, Organizations and Pin out details, Instruction sets, Assembly language programming, Micro operations of instructions. (6)
Memory Classification: ROM, EPROM, EEPROM, RAM, Memory Interfacing with 8085, Address decoding for Memory mapped I/O and I/O mapped I/O. (4)
Various types of Interrupts. (2)
Programmable Peripheral Devices and Interfacing with 8085: 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications. (6)
Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports. (5)
Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital</td></tr>
</table>

	converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. (5) ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc. (4) Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (5)
Text Books, and/or reference material	Text Books: 1. The 8085 Microprocessor: Author: Ramesh Gaonkar, Pub: PRI 2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi& J. G. Mazidi. 3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd. 4. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. Reference Books: 1.Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1		2	1	3	1	1	1	
CO2	3	1	2	1	1			1				1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1
CO5	3	3	3	1								1

Correlation levels 1, 2 or 3 as defined below:

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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE720</td><td>DIGITAL SIGNAL PROCESSING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the properties signals and systems.
• CO2: To understand the concept of signal processing.
• CO3: To analyse discrete time signals and systems in time as well as frequency domain.
• CO4: To design digital filters.
• CO5: To get acquainted with digital processors recently used.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Signals, systems and signal processing, concept of frequency in continuous and discrete time signal. (2)
Discrete-time Signals and Systems: Discrete time signals and systems, analysis of LTI</td></tr>
</table>

	system and implementation correlation. (6) Z-transform: Review, Analysis of LTI system in z-domain. (4) Frequency Domain Analysis: Frequency analysis of continuous-time and discrete-time signals and LTI systems, LTI system as frequency selective filter, inverse system and de-convolution. (6) Discrete Fourier Transform: Properties and Applications, Analysis using DFT. (6) Fast Fourier Transform Algorithms: FFT algorithms and Applications, linear filtering approach to computation of DFT. (6) Implementation of Discrete-Time System: FIR system, IIR system, representation of numbers, quantization of filter coefficients, round-off effects. (2) Design of Digital Filters: Design of FIR and IIR filters. (6) DSP Processors. (2) Recent Developments. (2)
Text Books, and/or reference material	Text Books: 1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles Algorithms and Applications, Pearson Education, 2005 2. A. V. Oppenheim, R. W. Schafer, Digital Signal Processing, Pearson Education, 2004 Reference Books: 1. S. K. Mitra - Digital Signal Processing: A computer-based approach, TMH, 2001 2. L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Pearson Education,

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	2	3	2	2
CO2	3	3	3	2	3	1	1	1	2	3	2	2
CO3	3	2	2	2	2	1	1	1	2	3	2	2
CO4	3	3	3	2	2	1	1	2	2	3	2	2
CO5	3	2	3	2	3	1	1	1	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE721	DESIGN OF FLIGHT CONTROL LAW	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CONTROL SYSTEMS (EEC502)		CT+MT+EA					
Course Outcomes	• **CO1:** To develop the concept of the aerodynamics, 6 degrees of freedom motion of aircraft and understanding the role of control surface for aircrafts and missile. • **CO2:** To understand the longitudinal & lateral dynamics of aircrafts & missile and to identify different modes along with the scope of improvement by designing control law. • **CO3:** To develop the concept of Static and Dynamic Stability.						

	• **CO4:** To develop insight on margin criterion, the closed loop response specifications and their relationship with the stability and flying qualities of the aircrafts. • **CO5:** To design control law based on Classical Control Theory for Autopilots, Longitudinal and Lateral/directional dynamics to meet the desired margin and flying qualities criteria • **CO6:** To design control law based on Classical Control Theory for Longitudinal and Lateral/directional dynamics to meet the desired margin and flying qualities criteria
Topics Covered	**Motions of Aircraft:** Primary Definitions, 6 DOF Motion, Aerodynamic Angles, Forces and Torques, Aircraft Position and Orientation, Stability-Frame and Body-Frame, Euler's Equations, Overview of missile equation of motion (3) **Linearization of Equations of Motion:** Small Disturbance Theory and Linearization of Equations of Motion, Stability and Control Derivatives in brief (2) **Longitudinal Dynamics:** Aircraft Longitudinal Dynamics, Longitudinal Motion Approximations, Short period mode, Phugoid mode, Influence of Stability Derivatives, Transfer Functions, Flying Qualities (5) **Lateral Dynamics:** Aircraft Lateral Dynamics, Lateral-Directional Equations, Dutch Roll, Roll and Spiral Modes, Approximate Models, Transfer Functions, Flying Qualities (5) **Stability and Control:** Static Stability Basics, Longitudinal static stability, Lateral/directional static stability, Dynamic Stability (3) **Classical Design Techniques for Flight Control:** Review of Control System Analysis/Synthesis Techniques, Closed loop performance specifications, Longitudinal Stability Augmentation System and Control Augmentation System Designs, Lateral Stability Augmentation System and Control Augmentation System Designs, Design for Aileron to Rudder interconnect gain, Concept of Autopilot design, Design of 2 Loop, 3 Loop Roll Autopilot for design (12) **Advanced Design Techniques for Flight Control:** Design of longitudinal and lateral Stability Augmentation System using Pole Placement, Linear Quadratic Regulator with Output feedback, Linear Quadratic Regulator with full state feedback, Designing Performance Index, Tracking a command (12)
Text Books, and/or reference material	Suggested Text Books: 1. Aircraft Control and Simulations by Stevens and Lewis, Wiley and Sons, 3rdEdn 2. Dynamics of Flight Stability and Control by Etkin and Reid, John Wiley & Sons, 3rdEdn Suggested Reference Books: 1. Flight Stability and Automatic Control by Nelson, WCB/McGraw-Hill, 2ndEdn 2. Introduction to Flight by Anderson, McGraw-Hill, 2ndEdn 3. Guided Weapon Control Systems by Garnell and East, 1stEdn, Pergamon Press, 1980 4. Missile Guidance and Control Systems by Siouris, 1stEdn, Springer Science & Business Media, 2004

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	1	2	1	3	1	1	1
CO2	2	2	3	1	2	1	2	1	2	1	1	1
CO3	3	3	3	2	2	1	2	1	3	1	1	1
CO4	3	3	2	2	1	1	2	1	3	1	1	1
CO5	3	3	3	2	2	1	3	1	2	1	1	1
CO6	2	3	3	2	3	2	3	1	3	1	1	1

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<table>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE 722</td><td>POWER SYSTEM RESTRUCTURING & DEREGULATION</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC 601: ADVANCED POWER SYSTEMS
EEE 714: POWER SYSTEM PLANNING, OPERATION OF CONTROL SYSTEM AND STABILITY</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the basic concept of regulation and deregulation or restructuring in the power system.
• CO2: Learn about bundled and unbundled power system structure.
• CO3: Acquire knowledge about different type of market models and its operations.
• CO4: To become an entrepreneur or can become a consultant in power system bussiness and operation.
• CO5: To understand the electricity power business and technical issues in a restructured power system in both Indian and world scenario.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction – Market Models, Power market Entities, Key issues in regulated and deregulated power markets [4]
Deregulation of electric utilities, Competitive whole sale electricity market: Transmission expansion in new environment, Transmission open access, pricing electricity in deregulated environment [7]
Fundamentals of Deregulation: Privatization and deregulation, Motivations for Restructuring the Power industry; Restructuring models and Trading Arrangements: Components of restructured systems, Independent System Operator (ISO): Functions and responsibilities, Trading arrangements (Pool, bilateral & multilateral) [10]
Different models of deregulation: U K Model, California model, Australian and New Zealand models, Deregulation in Asia including India, Bidding strategies, forward and Future market [8]
Available Transfer Capability, Congestion management, Ancillary services. Wheeling charges and pricing: Wheeling methodologies, pricing strategies [6]
Power Market Development – Electricity Act, 2003 - Key issues and solution; Indian power market, Congestion Management, Day Ahead Market [6]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. Loi Lei Lai, ‘Power System Restructuring and Deregulation’, John Wiley & Sons Ltd., 2001.
2. Lorrin Philipson, H. Lee Willis, ‘Understanding Electric Utilities and Deregulation’ Taylor & Francis, 2006.
REFERENCE BOOKS:
1. Mohammad Shahidehpour, MuwaffaqAlomoush, ‘Restructured Electrical Power Systems’,Marcel Dekker, Inc., 2001.
2. Mohammad Shahidehpour, Hatim Yamin, ‘Market operations in Electric power systems’, John Wiley & son ltd., 2002.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	2	1	0	0	0	0	1
CO2	2	2	2	1	2	2	1	0	0	0	0	1
CO3	3	3	3	2	2	2	1	0	0	0	0	1
CO4	2	2	2	2	2	2	1	1	1	1	1	1
CO5	2	2	3	2	2	2	1	0	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES751	MICROPROCESSORS AND MICROCONTROLLERS LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC403 (DIGITAL ELECTRONICS)		CT+EA					
Course Outcomes	• CO 1: Programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller. • CO2: Implementing key H/W and S/W attributes of microprocessors/microcontrollers. • CO3: Programming for various interfacing hardware • CO4: Programming in C/C++ language for typical microprocessor-based system.						
Topics Covered	List of Experiments 1. 8085/8051/8086 assembly language programming practice 2. µP/µC controlled stepper motor drive 3. µP/µC controlled 7-segment display control 4. µP/µC controlled digital I/O 5. µP/µC controlled elevator simulator 6. µP/µC controlled DAC & ADC 7. µP/µC controlled traffic light simulation control 8. µP/µC controlled keyboard display control						
Text Books, and/or reference material	Suggested Text Books: 1. Douglas V. Hall, Microprocessors and interfacing: programming and hardware, Tata Mc-Graw Hill 2. Badri ram, Advanced Microprocessors and Interfacing, Tata McGraw-Hill Publishing Co. Ltd. 3. Ramesh Gaonkar, The 8085 Microprocessor, PHI						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	3	3	2	1	1	1	1	1
CO2	3	1	2	1	3	3	2	1	1	1	1	1
CO3	3	3	3	3	3	3	2	2	1	1	1	1
CO4	3	3	3	3	3	1	2	2	1	1	1	1

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES752</td><td>ADVANCED POWER SYSTEM LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC401(POWERSYSTEMS-I)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand the Electric Field Distribution and concept of Dielectric strength of insulating material
• CO2: Able to measure and calibrate the high Voltage with sphere-sphere gap electrode combination.
• CO3: Able to conduct the destructive test i.e., high voltage test of gaseous, liquid and solid insulation and high Voltage power apparatus
• CO4: Able to conduct the non-destructive test of high Voltage power apparatus</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of experiments:
1. Analysis of Electrostatic Field in a Parallel Plate Capacitor Using Single & Multi Dielectrics
2. Calibration of Power frequency High Voltage and Measurement of Partial Discharge with sphere-sphere gap arrangement
3. Study the Characteristics of Impulse Voltage and the wave shape of Lighting impulse voltage
4. Study of Capacitance & Tan Delta of insulating material
5. Study the variation of Volume Resistivity of Transformer oil with temperature
6. Power Frequency Withstand Voltage test on 11 kV High voltage line materials
7. Measurement of BDV, Flash point and Fire point of Insulating oils
8. Study of Paschen’s Law and insulation resistance of paper
9. Survey of lighting in the classroom and spatial magnetic field in the vicinity of overhead power lines.
10. Survey of Magnetic field in 33KV power line and surrounding of 33/11KV and 11kV/415 V substation.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Laboratory Manuals</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	3	3	2	1	1	1	1	1
CO2	3	1	2	1	3	3	2	1	1	1	1	1
CO3	3	3	3	3	3	3	2	2	1	1	1	1
CO4	3	3	3	3	3	1	2	2	1	1	1	1

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES753</td><td>ELECTRICAL MACHINE DESIGN SESSIONAL</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC402 (ELECTRICAL MACHINES -I), EEC501 (ELECTRICAL MACHINES - II)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Students will be able to use standard methods to determine accurate modeling/simulation parameters for various general-purpose transformers and induction machines.
• CO2: Students will be able to know the relationship between the design variables; current density, electric fields, flux density, weight etc.; and how their interaction effects the design performance.
• CO3: Students will be able to choose appropriate materials for electrical machine design.
• CO4: Students will be able to use modeling/simulation parameters with standard equivalent circuit models to predict correctly the expected performance of various general-purpose transformers and induction machines.
• CO5: Students will be able use accepted national and international standards to select appropriate electrical machines to meet specified performance requirements.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Design of Transformer: Output equation, Optimum design, Design of core, Design of yoke, Window dimensions, Design of windings, Design of insulation, Overall dimensions. (12)
Transformer Design Details: Resistance of winding, Leakage reactance of winding, Regulation and Efficiency, Temperature rise, Cooling. (9)
Design of Induction Motors: Output equation, Standard frame size, Stator core, Shape and number of stator slots, Stator winding, Length of air gap, Rotor core, Design of rotor bars and slots, Design of end rings, No load current, Losses and Efficiency, Temperature rise. (21)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. A. K. Sawhney & A. Chakrabarti, Electrical Machine Design, Dhanpat Rai & Co.
Reference Books:
1. S. K. Sen, Principles of Electrical Machine Design with Computer Programs, Oxford & IBH Publishing Company Pvt. Limited.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	1	1	1	2	3
CO2	3	3	3	3	3	3	1	1	1	1	2	3
CO3	3	3	3	3	3	3	1	1	1	1	2	3
CO4	3	3	3	3	3	3	2	1	2	2	3	3
CO5	2	2	2	2	2	2	2	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

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Semester - VIII						
Code	**Subject**	**L**	**T**	**S**	**C**	**H**
EEE810 --	Depth Elective - 6	3	0	0	3.0	3
YYO84*	Open Elective - 4	3	0	0	3.0	3
YYO85*	Open Elective - 5	3	0	0	3.0	3
EES851	Project - II	0	0	15	5.0	15
EES852	Project Seminar	0	0	0	1.0	0
EES853	Viva Voce	0	0	0	1.0	0
	TOTAL	9	0	15	16.0	24

2018 ONWARD UNDERGRADUATE ADMISSION BATCH

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT

Departmental Elective: EIGHTH SEMESTER

Subject Code	Subject Name
EEE810	Power System Transients & Power Quality
EEE811	Smart Grid
EEE812	Power system Reliability

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE 810	POWER SYSTEM TRANSIENTS & POWER QUALITY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC 301 (NETWORK ANALYSIS AND SYNTHESIS)		CT+MT+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Get an idea about nature of power system transients and analyze the electrical transients in power systems. • CO2: Understand causes of the transients and how these can be reduced or eliminated. • CO3: Acquire knowledge of various power quality problems like transients and harmonics etc, their mitigation and measuring techniques. • CO4: Apply the concept of power system transients and power quality to solve various power system abnormal situations.						

	• CO5: Evaluate the response of power system in presence of various transient & power quality related issues. • CO6: Design various circuits to protect power system in presence of various transient & power quality related issues.
Topics Covered	**Fundamental Notions about Electrical Transients: -** Introduction, Circuit Parameters, Mathematical Statement of the Problem and its physical Interpretation, The Principle of Superposition (2) **Simple Switching Transients: -** The circuit closing Transient, the recovery Transient initiated by the removal of a short circuit, Double frequency transients (3) **Damping: -** Some observation on the RLC circuits, the generalized damping curves, Resistance Switching, Load Switching, Other forms of damping, Damping and frequency (3) **Abnormal Switching Transients: -** Normal and abnormal Switching Transients, Current suppression, Capacitance switching, Transformer Magnetizing Inrush Current, Ferro resonance (4) **Transients in DC circuits: -** Introduction, Interruption of Direct Current in low voltage circuits, Transients associated with HVDC circuit Breakers, Commutation Transients- The current Limiting static circuit breaker (3) **Travelling waves and other Transients on Transmission Lines: -** Circuit with distributed constants, the wave equation, Reflection and Refraction of travelling waves, Behaviour of Travelling waves at line termination, Lattice Diagram, Attenuation and Distortion of Travelling waves, switching operation involving Transmission Lines. (4) **Protection of systems and Equipments against Transient Overvoltages:-** Protection of Transmission Lines against Lightning, Lightning Shielding of substation, Surge Suppressors, Surge Capacitors and Reactors, Surge Protection of Rotating Machines (7) **Introduction to Power Quality: -** Definition of Power Quality, Power Quality Terminology, Power Quality Issues, Power Quality Progression (2) **Power Frequency Disturbance: -**Common Power Frequency Disturbances, Voltage Sags, Cure for Low-frequency Disturbances, Isolation Transformers, Voltage Regulators (3) **Harmonics:-** Definition, Harmonic Number, Odd and even harmonics, Harmonic Phase Rotation and Phase angle Relationship, Causes of voltage and current harmonics, Individual and Total Harmonic Distortion, Harmonic Signatures-Fluroscent Lighting, Adjustable Speed Drives, Personal Computer and Monitor, Effect of Harmonics on Power System Devices- Transformers, AC Motors, Capacitor Banks, Cables, Busways, Protective devices, Harmonic Current mitigation- Equipment Design, Harmonic Current Cancellation, Harmonic Filters (7) **Power Quality Measuring Devices and Measurement: -** Harmonic Analyzers, Transient-Disturbance Analyzers, Oscilloscopes, Data Loggers and Chart Recorders, True RMS Meters, Power Quality Measurement (5)
Text Books, and/or reference material	**Text Books:** 1. "Electrical Transients in Power Systems", by Allan Greenwood; John Wiley & Sons; 2nd edition, April 1991. 2. "Power Quality", by C. Sankaran; First Indian reprint, CRC press; 2009. **Reference Books:** 1. "Power system transients: A Statistical approach", by C. S. Indulkar and D. P. Kothari; PHI Learning Private Ltd., 2nd edition 2010. 2. "Understanding Power Quality Problems: Voltage Sags and Interruptions", by Math H.J. Bollen; IEEE Press, 2001. 3. "Power System Quality Assessment", by J. Arrillaga, N. R. Watson, S. Chen; John Wiley & Sons, 2000. 4. "Transients in power systems", H.A.Peterson; Dover Publications, New York, 1963

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	0	1	0	0	0	0	0
CO2	2	2	2	1	1	1	1	0	0	0	0	0
CO3	2	3	3	1	1	1	1	0	0	0	0	0
CO4	2	3	3	1	2	2	1	0	0	0	0	1
CO5	2	2	2	2	2	1	2	0	1	0	1	0
CO6	2	2	3	1	2	1	2	0	1	0	1	1

Correlation levels 1, 2 or 3 as defined below:

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<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEE811</td><td>SMART GRID</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td colspan="2">3</td></tr>
<tr><td colspan="4">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="4">EEC601 (ADVANCED POWER SYSTEMS),
EEE714 (POWER SYSTEM PLANNING, OPERATION OF CONTROL SYSTEM AND STABILITY)</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: To understand various aspects of smart grid
• CO2: To study various smart transmission and distribution technologies
• CO3: To appreciate distribution generation and smart consumption and know the regulations and market models for smart grid
• CO4: To realize the operation of various Systems and its Functions used in the smart grid.
• CO5: To know about the initiative, present status, future aspects and development for smart gird.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Introduction: Smart Grid Concept, overview of Micro Grid, Green Grid, Intelligent Grid and Smart Grid, Necessity of Smart Grid. (2)
Impact of Smart Grid: Business Value Chain Generation, Transmission and Distribution, Customer Services, Market, Original Equipment Manufacturer (OEM). (3)
Fundamental Infrastructure: Concept of ElectrinetSM, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation, Attributes of Smart Grid, Complexity and Standard Organization. (4)
Architecture of Smart Grid: Visualizing the Power System in Real Time, Framework of Smart Grid, Increasing System Capacity, Relieving Bottlenecks, Enabling a Self-Healing Grid, Enhanced Connectivity to Consumers, Fast Simulation and Modeling, Energy Resources in Advanced Automation. (7)
Systems And Functions: Distributed Control System (DCS), Energy Management Systems (EMS), Supervisory Control and Data Acquisition (SCADA), Distribution Automation (DA), Power Electronics-Based Controllers, Power Market Tools Advanced Meter Infrastructure (AMI), Demand Response, Distributed Energy Resources (DERs), Distributed Generation (DG), Electric Vehicle (EV), Energy Storage (ES). (8)
Electric Energy Efficiency: Power Plant Electricity Use, Electric Energy Efficiency in Power Production & Delivery, Efficiency in Power Delivery, Conservation Voltage Reduction. (4)</td></tr>
</table>

	Perfect Power System: Vision of Perfect Power System, Perfect Electric Energy Service System, Design Criteria, Perfect Power System Configurations, Fully Integrated Power System, Smart Grid Module with Core Factors, Graphical Representation of Smart Grid Features. (6) Smart Grid Progress: Status of Smart Grid in European Country, US, Present Power Scenario in India, Recent Initiatives, Strategy and Planning to Implement Smart Grid in Developed and Developing Countries. (6)
Text Books, and/or reference material	Text Books: 1. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, distributed & Efficient Energy", Academic Press (imprint of Elsevier), 2012. 2.Andres Carvallo, John Cooper, "The Advanced Smart Grid: Edge Power Driving Sustainability", Artech House, Boston London, 2011 Reference Books: 1.Clark W. Gellings, "The smart grid: enabling energy efficiency and demand response", The Fairmont-CRC Press, 2010. 2.JamesMomoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley-IEEE Press, 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	1	1	0	0	0	0	0
CO2	2	2	3	1	1	1	1	0	1	0	0	1
CO3	2	3	3	2	2	2	1	0	1	0	0	1
CO4	2	3	2	1	2	2	1	0	1	0	0	1
CO5	2	2	3	1	2	2	1	0	1	0	0	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEE812	Power system Reliability	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
EEC401(POWERSYSTEMS-I) EEC501(POWER SYSTEMS–II), EEC 601: ADVANCED POWER SYSTEMS			CT+MT+EA				
Course Outcomes	CO1: Understand the importance of maintaining reliability of power system components CO2: Assess the different models of system components used in reliability studies. CO3: Apply expressions for Reliability analysis of series-parallel and Non-series parallel systems in practical power systems. CO4: Evaluate reliability of generation, transmission and distribution systems using different reliability indices. CO5: Analyse required for generation, transmission and distribution systems expansion. CO6: Design reliable power system considering generation, transmission & distribution together.						
Topics Covered	Basic Reliability Concepts: The general reliability function. The exponential distribution, Definition of different reliability indices, Mean time to failures, series and parallel systems,						

	Recursive techniques, Simple series and parallel system models. 8 Generating Capacity – Basic Probability Methods: The generation system model, Loss of load indices, Capacity expansion analysis, scheduled outages. Load forecast uncertainty Loss of energy indices. The frequency and duration method. 8 Transmission Systems Reliability Evaluation: Radial configuration, Conditional probability approach, Network configurations, State selection, System and load point Indices. 8 Distribution Systems Reliability Evaluation: Evaluation Techniques, Additional interruption indices, Effect of lateral distribution protection, Effect of disconnects. 6 Introduction to Power System Planning: Basic Principles, Power System Elements, Power System Structure , Power System Studies, Power System Planning Issues, Static Versus Dynamic Planning, Transmission Versus Distribution Planning, Long-term Versus Short-term Planning, Basic Issues in Transmission Planning 6 Single-bus Generation Expansion Planning: Problem Definition, Problem Description, Mathematical Development 2 Multi-bus Generation Expansion Planning: Problem Description, Mathematical Formulation 2 Network Expansion Planning: Problem Definition, Problem Description, Problem Formulation 2
Text Books, and/or reference material	**TEXT BOOKS:** 1. "Reliability evaluation of Engineering systems", Roy Billinton and Ronald N Allan, BS Publications. 2. "Reliability Engineering", Elsayed A. Elsayed, Prentice Hall Publications. 3. "Reliability Evaluation of Power Systems", Roy Billinton and Ronald Allan Pitam springer, 1996. 4. "Electric Power System Planning Issues Algorithms and Solutions", **Seifi**, Hossein, **Sepasian**, Mohammad Sadegh, Springer **REFERENCES:** 1. "Reliability Engineering: Theory and Practice", By Alessandro Birolini, Springer Publications. 2. "An Introduction to Reliability and Maintainability Engineering", Charles Ebeling, TMH Publications. 3. "Reliability Engineering", E. Balaguruswamy, TMH Publications.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	0	1	1	0	0	1	0	1
CO2	2	2	2	1	1	1	1	0	0	0	0	0
CO3	2	2	2	2	2	1	1	0	0	0	0	0
CO4	3	3	3	3	3	3	2	0	0	1	1	0
CO5	2	2	2	2	1	1	1	0	1	0	0	0
CO6	3	3	3	3	3	2	2	0	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in _____ Senate # ______________ # Item no: ______

DEPARTMENT OF MECHANICAL ENGINEERING

Program Name: Bachelor of Technology in Mechanical Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR MECHANICAL ENGINEERING- B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4	4
2	MEC301	Solid Mechanics	3	1	0	4	4
3	MEC302	Theory of Machines and Mechanisms	3	1	0	4	4
4	MEC303	Fluid Mechanics	3	1	0	4	4
5	MEC304	Engineering Thermodynamics	3	0	0	3	3
6	PHC333	Physics of Engineering Materials	3	0	0	3	3
7	PHS383	Physics of Engineering Materials Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0	0
		TOTAL	18	4	3	23.5	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MEC401	Design of Machine Element	3	1	0	4	4
2	MEC402	Casting, Forming and Welding	3	1	0	4	4
3	MEC403	Heat and Mass Transfer	3	0	0	3	3
4	EEC432	Electrical Machines	3	0	0	3	3
5	YYO44*	Open Elective - I	3	0	0	3	3
6	MES451	Solid Mechanics Laboratory	0	0	3	1.5	3
7	MES452	Fluid Mechanics Laboratory	0	0	3	1.5	3
8	MES453	Mechanism Laboratory	0	0	3	1.5	3
9	EES482	Electrical Machines Laboratory	0	0	3	1.5	3
10	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0	0
		TOTAL	15	2	12	23	29
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MEC501	Machining and Machine Tools	3	1	0	4	4
2	MEC502	IC Engine and Gas Turbines	3	0	0	3	3
3	MEC503	Machine Design	3	1	0	4	4
4	MEC504	Dynamics of Machines	2	1	0	3	3
5	YYO54*	Open Elective - 2	3	0	0	3	3
6	MES551	Design and Dynamics Laboratory	0	0	3	1.5	3
7	MES552	Heat Transfer Laboratory	0	0	3	1.5	3
8	MES553	CAD/CAM Laboratory	0	0	3	1.5	3
9	WSS581	Workshop Practice- II	0	0	3	1.5	3
	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0	0
		TOTAL	14	3	12	23	29

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3	3
2	MEC601	Power Plant Engineering	2	1	0	3	3
3	MEC602	Industrial Engineering and Measurement	3	0	0	3	3
4	MEE610 --	Depth Elective - 1	3	0	0	3	3
5	MEE610 --	Depth Elective - 2	3	0	0	3	3
6	MES651	Engineering Measurement Laboratory	0	0	3	1.5	3
7	MES652	Power Generation Laboratory	0	0	3	1.5	3
8	MES653	Machine Design Sessional - I	0	0	3	1.5	3
9	MES654	Manufacturing Laboratory	0	0	3	1.5	3
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0	0
		TOTAL	14	1	12	21	27
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3	3
2	MEE710 --	Depth Elective - 3	3	0	0	3	3
3	MEE710 --	Depth Elective - 4	3	0	0	3	3
4	MEE710 --	Depth Elective - 5	3	0	0	3	3
5	YYO74*	Open Elective - 3	3	0	0	3	3
6	MES751	Hydraulic Machine Laboratory	0	0	3	1.5	3
7	MES752	Machine Design Sessional - II	0	0	3	1.5	3
8	MES753	Vocational Training / Summer Internship and Seminar	0	0	3	1.5	3
9	MES754	Project - I	0	0	3	1	4
		TOTAL	15	0	12	20.5	27
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MEE810 --	Depth Elective - 6	3	0	0	3	3
2	YYO84*	Open Elective - 4	3	0	0	3	3
3	YYO85*	Open Elective - 5	3	0	0	3	3
4	MES851	Project - II	0	0	15	5	15
5	MES852	Project Seminar	0	0	0	1	0
6	MES853	Viva Voce	0	0	0	1	0
		TOTAL	9	0	15	16	24

CURRICULUM AND SYLLABUS FOR B.TECH. IN MECHANICAL ENGINEERING

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45	23.5	23	23	21	20.5	16	172

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF MECHANICAL ENGINEERING
MEE610	Automobile Engineering
MEE611	Gas Dynamics and Propulsion
MEE612	Mechanics of Forming and Press Working
MEE613	Advanced Solid Mechanics
MEE614	Advanced Machining and CNC Machine Tools
MEE615	Operation Research
MEE616	Mechanical Equipment Design
MEE620	Advanced Foundry Engineering
MEE621	Mechanics of Composite and Functionally Graded Materials
MEE622	Engineering Optimization
MEE623	Multi-Phase Flow and Heat Transfer
MEE624	Tribology
MEE625	Computer Aided Design and Manufacturing

7th Semester

	DEPARTMENT OF MECHANICAL ENGINEERING
MEE710	Finite Element Method
MEE711	Computational Fluid Dynamics and Heat Transfer
MEE712	Design and Optimisation of Thermal Systems
MEE713	Non-Conventional Machining
MEE714	Advanced Welding Technology
MEE715	Robotics
MEE716	Mechanical Equipment Design
MEE717	Control Systems
MEE718	Fundamentals of Combustion
MEE719	Modelling and Simulation of Dynamic Systems

MEE720	Non-Linear Vibration
MEE721	Convective Heat and Mass Transfer
MEE722	Additive Manufacturing
MEE723	Energy Conversion Systems
MEE724	Hydraulic Machines
MEE725	Introduction to Aerospace Engineering

8th Semester

	DEPARTMENT OF MECHANICAL ENGINEERING
MEE810	Solar Energy
MEE811	Mechatronics
MEE812	Micro and Nano Manufacturing
MEE813	Microfluidics
MEE814	Machine Tool Engineering and Automation
MEE815	Theory of Plates
MEE816	Advanced Mechanical Vibration

DETAILED SYLLABUS
FIRST SEMESTER

Semester - I								
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points,						

	Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course	CO1: To realize and apply the fundamental concepts of physics such as superposition						

Outcomes	principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC 01</td><td>Engineering Chemistry</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications
• CO2: To learn fundamentals of polymer chemistry and petroleum engineering.
• CO3: Introduced to basic spectroscopic techniques for structure determination and characterization.
• CO4: To study few inorganic and bioinorganic compounds of industrial importance.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
ORGANIC CHEMISTRY
i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb’s catalyst and Wittig reaction. (3)
ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3)
iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2)
iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)
v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3)
INORGANIC CHEMISTRY
i. Coordination Chemistry: Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5)
</td></tr>
</table>

	ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5^{th} Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5^{th} Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1^{st}, 2^{nd}, 3^{rd} and 4^{th} quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)						
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	WORKSHOP PRACTICE	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Study and practice on machine tools and their operations • CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding • CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping • CO4: Develop basic electrical engineering knowledge for house wiring practice
Topics Covered	**M/c shop & Carpentry shop -- 3X3= 9hrs.** • Introduction on machining process. • Introduction to machine tools- Lathe, Shaper, Milling and Drill machine. • Introduction to woods- Types, structure, disease and defect of wood. • Introduction to wood working machines and tools. • Making of dovetail joint and bridle joint. **Welding Shop & Sheet metal -- 3X3= 9hrs.** • Introduction to welding.Safety and precautions in welding. • Formation of weld bead by SMAW on mild steel flat. • Formation of weld bead by oxy-fuel welding on mild steel flat. • Introduction to sheet Metal works. • Tools and Machines used in sheet metal works. • Concept of development, marking out of metal sheets. • Cutting and joining of metal sheets. • Safety precautions, General warning needed in the shop floor. **Black smithy & Foundry -- 3X3= 9hrs.** • Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels. • Safety and precautions in blacksmithy. • Making of bars of different cross-sections. • Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology. • Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats.

	• Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))						
NIL	CT+EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar.						

	• Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET**

	• Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi),

	Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC 02</td><td>MATHEMATICS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic concepts of set theory, differential equations, and probability.</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
CO4: To grasp the basic concepts of probability theory.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Elementary algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (5)
Linear Algebra: Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)</td></tr>
</table>

	Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions,
	Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4) **Laplace and Fourier Transforms:** Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10^{th}ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3^{rd} Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's						

	(operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium 1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons 1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction						

	2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741,

	9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	ELECTRICAL TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))					
NIL		CT+MT+ EA					

Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts. • CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's • CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts. • CO4: introduce the basic concept of single-phase transformer. • CO5: analyze the transient phenomena in electrical circuits with DC excitation
Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC01</td><td colspan="2">LIFE SCIENCE</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism.
CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa
CO3: To introduce molecular biology to understand biological processes in various applications.
CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens.
CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">1. Cell Biology (4)
a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference
b) Introduction to cells - Define cell, different types of cell
c) Cellular organelles - All organelles and functions in brief
d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation
2. Biochemistry (4)
a) Biological function of carbohydrate and lipid - Introduction, structure and function
b) Biological function of nucleic acids and protein - structure and function
c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis,</td></tr>
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<tr><td></td><td>
TCA; overall degradation of proteins and lipids
d) Biosynthesis of Macromolecules
Generation of ATP (ETS), Generation of Glucose (Photosynthesis)
3. Microbiology (5)
a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases
b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc,
c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve
d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle
4. Immunology (5)
a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system
b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody
c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination
d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell
5. Molecular Biology (5)
a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear
b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin
c) Central Dogma (Replication, Transcription and Translation)
d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning
6. Bioprocess Development (5)
a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation
b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation
Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki
c) Microbial sterilization techniques and kinetics
Introduction to sterilization, dry and moist sterilization
d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions
e) Material and energy balance for biological reactions - Stoichiometry
</td></tr>
<tr><td>Text Books, and/or reference material</td><td>
1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD.
2. Biochemistry by Lehninger. McMillan publishers
3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill
4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992
5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition,
</td></tr>
</table>

	Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)						

Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS51</td><td>COMPUTING LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques
• CO2: To detail out the operations of strings
• CO3: To understand structure, union
• CO4: Application of C-programming to solve various real time problems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
1. Assignments on expression evaluation
2. Assignments on conditional branching, iterations, pattern matching
3. Assignments on function, recursion
4. Assignments on arrays, pointers, parameter passing
5. Assignments on string using array and pointers
6. Assignments on structures, union</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Let us C by Kanetkar
2. C Programming by Gottfried
3. Introduction to Computing by Balaguruswamy
4. The C-programming language by Dennis Ritchie
Reference Books:
1. Computer fundamental and programming in C by P Dey and M. Ghosh
2. Computer fundamental and programming in C by Reema Thareja
3. programming with C by Schaum Series</td></tr>
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Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS 51</td><td>Basic electronics Lab</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire idea about basic electronic components, identification, and behavior.
• CO2: To determine IV characteristics of these Circuit elements for different applications.
• CO3: Learn to analyze the circuits and observe and relate input and output signals.</td></tr>
<tr><td>Labs Conducted.</td><td colspan="7">1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments.
2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it.
3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms.
4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.
5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs
6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs
7. Transistor as a Switch: study and perform transistor as a switch through NOT gate
8. Zenner diode as voltage regulator
9. To study clipping and Clamping circuits
10. To study different biasing cirtis.
11. Study of CE amplifier and observe its frequency response.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al.
<u>Reference Books</u>:
1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill
2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	•CO1: understand the principle of superposition. •CO2: understand the principle of maximum power transfer •CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. •CO4: understand the calibration of energy meter. •CO5: understand open circuit and short circuit test of single-phase transformer. •CO6: analyze RLC series and parallel circuits •CO7: understand three phase connections. •C08: understand determination of B-H curve
Topics Covered	**List of Experiments:** 1.To verify Superposition and Thevenin's Theorem. 2.To verify Norton and Maximum power transfer theorem 3.Characteristics of fluorescent and compact fluorescent lamp 4.Calibration on energy meter 5.To perform the open circuit and short circuit test on single phase transformer 6.To study the balanced three phase system for star and delta connected load 7.Characteristics of different types of Incandescent lamps 8.Study of Series and parallel R-L-C circuit 9.Determination of B-H Curve for magnetic material
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma , H U Ezea 2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XXS-52	Co-curricular Activities	PCR	0	0	2	2	1
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball.						

	• Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service.

	• Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CO-PO Mapping and Matrix

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	3	3	1	2	-	-	-	-	1	-	-	-
	CO2	3	3	1	2	-	-	-	-	1	-	-	-
	CO3	3	3	1	2	-	-	-	-	1	-	1	1
	CO4	3	-	-	2	-	2	-	-	1	-	-	-

PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1
CYC01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-
MAC02	CO1	2	3	1	3	-	-	-	-	2	-	-	-
	CO2	2	3	1	2	-	-	-	-	2	-	-	-
	CO3	2	2	2	3	2	-	-	-	3	-	1	1
	CO4	2	3	2	3	2	1	1	-	2	-	-	-
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

ECC01	CO1	-	-	-	-	-	-	-	-	-	-	-	-
	CO2	-	-	-	-	-	-	-	-	-	-	-	-
	CO3												
	CO4	-	-	-	-	-	-	-	-	-	-	-	-
EEC01	CO1	3	1	-	-	2	-	-	-	-	1	-	-
	CO2	2	3	2	-	2	-	-	-	-	-	-	-
	CO3	2	3	1	-	-	-	-	-	-	1	-	-
	CO4	3	1	2	-	1	-	-	-	-	-	-	-
	CO5	3	1	2	-	1	-	-	-	-	-	-	-
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-
EES51	CO1	3	-	2	-	3	-	-	-	1	-	-	-
	CO2	3	-	2	-	3	-	-	-	1	-	-	-
	CO3	2	3	2	2	1	-	2	-	1	-	-	-
	CO4	2	3	1	2	2	-	1	-	1	1	-	-
	CO5	2	3	1	2	2	-	-	-	1	-	-	-
	CO6	2	3	2	2	2	-	-	-	1	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

THIRD SEMESTER

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td>Mathematics-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Basic knowledge of topics included in MAC01 & MAC02</td></tr>
</table>

Course Outcomes	CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. CO4: To understand the optimization methods and algorithms developed for solvingvarious types of optimization problems.
Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem.[17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP.[9]

Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K.Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 301	**Solid Mechanics**	PCR	**3**	**1**	**0**	**4**	**4**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Basic knowledge on Engineering Mechanics	CT+EA
Course Outcomes	CO1 Knowledge on the analysis of stress, strains, elasticity properties of materials, strain energy principles CO2 Exposure towards members subjected to shear force, bending moments, flexure loads, torsional loads CO3 Idea about analyzing deflection of beams CO4 Acquire the fundamentals about members subjected to compressive loads.
Topics Covered	Introduction to stress and strains, Generalized Hooke's Law, Relationship among different elastic coefficients. 4 Theory of Bending, Shearing Forces and Bending Moments in beams, SF and BM Diagrams.6 Bending Stresses in Beams, Flexural rigidity, Section Modulus, Shear Flow, Shear Centre.6 Deflection of Beams: Double-Integration method, Area-Moment method;Propped cantilever and Fixed beams.6 Statically indeterminate beam problems. 4 Torsion of Circular shafts.4 Analysis of bi-axial stress and Mohr's Circle. 6 Combined Loading and Theories of Failure. 4 Columns: Buckling of columns, Euler's formula for stability of column. 6 Stresses in Thin Cylinder 2 Strain Energy methods – Castigliano's Theorem. 4
Text Books, and/or reference	**Text Books:** 1. Strength of Materials: Part I, II, S. Timoshenko, CBS Publishers, 1985. 2. Engineering Mechanics of Solids, E. P. Popov, PHI, 1993.

material	**Reference Books:** 1. Introduction to Solid Mechanics, I. H. Shames and J. M. Pittariesi, PHI, 2003. 2. Strength of Materials, F. L. Singer and A. Pytel, Harper Collins Publishers, 1991

Department of Mechanical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 302	**Theory of Machines & Mechanisms**	PCR)	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Mechanics		CT+EA					

Course Outcomes	CO1 Knowledge of dynamics of elementary mechanisms and machines CO2 Knowledge of the fundamental of machine design
Topics Covered	Introduction to Mechanisms Linkages, Mechanisms and machines; Kinematic pair, element, chains and inversions; degrees of freedom, mobility and Gruebler's criterion; four bar mechanisms and slidercrank mechanismsSpecial Mechanisms - Indicator Diagram Mechanisms, Steering Mechanism, Hookes Joint4 Kinematics of Rigid Bodies Frame of reference in general motion, General plane motion, absolute and relative velocity in plane motion, Instantaneous center of rotation in plane motion3 Kinetics of Rigid Bodies in 3D Plane motion of rigid bodies: Force and accelerations methods, Energy and momentum methods3 Kinematic Analysis of Planar Linkages Position & displacement analysis, Velocity analysis, Acceleration analysis9 Gears& Gear trains: Fundamental law of gearing, gear tooth terminology, gear type, contact ratio & Kinematics analysis, Kinematic analysis of Gear trains:Velocity ratio and sense of rotation; simple, compound and epicyclic gear trains7 Cam Mechanisms: Cam terminology, displacement diagram, graphical layout of cam profile. 2 Kinematic Synthesis of Planar Linkages: Type, number and dimensional synthesis, Body guidance, path and function generation, Analytical linkage synthesis4 Computer Aided Mechanism Analysis 1 Dynamic Force Analysis of Machines Dynamic force analysis for slider crank mechanism; inertia forces in reciprocating parts; primary and secondary inertia forces; simple engine mechanism – gas force, piston effort, gudgeon pin load, crank effort or turning moment; single and double acting engine; inertia force analysis

	considering mass of the connecting rod; force analysis for a four bar mechanism6 Flywheels:Turning moment diagram, indicator diagrams – mean effective pressures for suction, compression, expansion and exhaust strokes; overall mean effective pressure for the cycle; mean resisting torque; fluctuation of energy and speed; flywheel6 Governor Mechanisms:Types, characteristics of centrifugal governors; conical pendulum type governors – Watt, Porter, and Proell; Spring loaded type of governors – Hartnell; controlling force, effort, power, sensitiveness, isochronism, stability and hunting of governors 5
Text Books, and/or reference material	**Text Books:** 1. Theory of Machines and Mechanisms, Uicker J.J., Pennock G.R., Shigley J.E. 2. Theory of Mechanisms and Machines, Ghosh A., Mallik A.K.
	Reference Books: 1. Introduction to the mechanics of machines, Morrison J.L.M., Crossland B.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC303	**Fluid Mechanics**	PCR	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1 Fundamental of Engineering fluid mechanics						
Topics Covered	I. Introduction: 08 Definition of fluid; Concept of continuum and Knudsen number; Concept of velocity, pressure and stress fields; Stress tensor; Fluid properties; Slip and no-slip; Compressibility and bulk modulus; Vapour pressure; Surface tension; Capillary rise and depression. II. Kinematics of flow and flow measurements: 08 Definition of flow field; Lagrangian and Eulerian description of fluid motion; Substantial derivative; Reynold's Transport Theorem; Integral form of conservation equations of fluid motion; Acceleration field; Pathline, streamsline, streakline, timeline and stream tube; Pure translation, rotation and linear and angular deformation of fluid element; angular velocity; vorticity and circulation; Free and forced vortex flows; Euler's equation along streamline; Bernoulli's Equation; Static, stagnation and dynamic pressures: Application of Bernoulli's Equation. III. Differential analysis of fluid motions: Differential control volume:08 Conservation of mass; conservation of momentum; Stokes's hypothesis; Navier-Stokes equation; Euler's equation of motion of an ideal fluid; Exact solutions of NS equations for steady incompressible flow: plane Poiseuille flow, Couette Flow, falling film flow,.						

	IV. Incompressible Flow through pipes and ducts:06 Hagen-Poiseuille flow, Darcy Wesibach Equation, Major and minor losses, Surge control; V. Dimensional Analysis:04 Measurement and dimension; Variables and functions; Dimensional homogeneity; Pi Theorem; Dimensionless parameters; Scaling rules, dimensionless numbers; Similitude; Similarity solutions and transformations; Geometric and dynamic similitude. VI. Boundary layer flows: 06 Boundary layer concepts; Prandtl's boundary layer equations; Blasius Equation for flow over a flat plate; Momentum integral equations for boundary layers; Wall shear stress; Separation of boundary layers; Fluid flows about immersed bodies. VII. Potential flow: 06 Irrotational flow; Velocity potential and stream function; Stream function for two-dimensional incompressible flow; Laplace equation; Method of solution; Complex potential for fundamental flows; Superposition of elementary flows; Flow about a half body; Uniform flow past a source and a sink, a doublet, and a cylinder with circulation; Aerofoil theory. VIII. Compressible flow:06 Propagation of sound wave; Types of flow regimes: Mach cone; Stagnation and critical states; Isentropic flow of an ideal gas: area variation; Isentropic flow in converging and converging-diverging nozzle; normal shock.
Text Books, and/or reference material	**Text Books:** 1. Introduction to Fluid Mechanics: Fox 2. Fluid Mechanics: Munson and Okiish 3. Fluid Mechanics: Robert Granger
	Reference Books: 1. Fluid Mechanics: Frank M. White 2. Mechanics of Fluids: B. S. Massey

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC304	**Engineering Thermodynamics**	PCR	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1 Knowledge of thermo-dynamical system CO2 Mastering laws of thermodynamics CO3 Study of air standard thermodynamic cycles CO4 Properties of pure substance CO5 Thermodynamic relations						

Topics Covered	Reynolds transport theorem based reformulations of conservation principles 2 PVT and non-PVT equation of states, Important slopes and projections. 2 Zeroth law of thermodynamics: Concept of temperature 1 First law of thermodynamics: Concept of heat, work and energy 2 Second law of thermodynamics: Concept of Entropy 2 Gouy-Stodola theorem: Exergy analysis, Some aspects of entropy generation minimization 1 Third law of thermodynamics: Nernst heat theorem 1 Thermodynamic relations: Partial derivatives, Maxwell relations, Thermodynamic mnemonic diagram 2 Applications of SFEE 1 Heat engine, heat pump and refrigerators. First and second law based performances 2 Air standard cycles: Carnot, reversed Carnot, Otto, Diesel, dual, Joule-Brayton, reversed Joule-Brayton 5 Properties of pure substances: Steam table, Mollier diagram, P-h chart 6 Vapour power cycles: Rankine, reheat, regenerative, binary vapour cycles 6 Reciprocating air compressor: Single stage air compressor, isothermal efficiency, clearance and clearance volume, volumetric efficiency, two stage and multistage compression, Intercooler, heat rejected per kg. air, indicator diagram, mean effective pressure, Mechanical efficiency 4 Rotary compressor: Roots blower, vane type blower, rotary dynamic compressor, centrifugal compressor. Momentum principles and Euler's equation for energy transfer. Static and total head quantities, velocity diagrams 3
Text Books, and/or reference material	**Text Books:** 1. M. J. Moran, H. N. Shapiro, Fundamentals of Engineering Thermodynamics, Wiley. 2. R. E. Sonntag, C. Borgnakke, G. J. Van Wylen, Fundamentals of Thermodynamics, Wiley. 3. P. K. Nag, Engineering Thermodynamics, McGraw-Hill. 4. D. K. Kondepudi, I. Prigogine, Modern Thermodynamics, Wiley. 5. J. F. Lee, F. W. Sears, Thermodynamics, Addison Wesely
	Reference Books: 1. E. P. Gyftopoulos, G. P. Beretta, Thermodynamics: Foundations and Applications, Dover. 2. A. Thess, The Entropy Principle, Springer.

Department of Physics							
Offered for Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC333	**Physics of Engineering Materials**	PCR	**3**	**0**	**0**	**3**	**3**

Course Outcomes	CO1: To understand fundamental theory of metal CO2: To comprehend theory and device applications of semiconductor materials CO3: To be familiar with fundamental of laser and its applications. CO4: To know about the super conductivity, dielectric and mechanical properties of material
Topics Covered	Electron Theory of Metals Fermi-Dirac Statistics and Fermi energy, Density of states, Concept of density of states in nanomaterials, Electrical conduction in metals and alloys, Current density, Drift velocity, Mobility etc., Classical electron theory of metal (Drude-Lorentz Theory), Quantum mechanical consideration (Sommerfeld Model). Origin of band gap (Kronig-Penny Model), Brillouin zone, Resistivity of pure metals and alloys, Electronic specific heat of metals, Thermal conductivity of metals, Factors affecting electrical conductivity, Resistivity of pure metals and alloys, Solders, Soft and hard and the use of fluxes and their classifications. [12L] Semiconductors Intrinsic and extrinsic semiconductors, Fermi level, Calculation of number density of carriers and their temperature dependence, Conductivity, Mobility and its temperature dependence, Hall effect. Compound semiconductors, Direct and indirect bandgap semiconductors. Applications of semiconductor material; Semiconductor devices, p-n diode, Zener diode, Tunnel diode, Solar cell. Semiconductor device fabrication (Mention only techniques). Double hetrostructure LED (ILED). [10L] Materials for Optical Applications Optical materials for Light Emitting Diode, Laser- Solid-state lasers, Liquid & Gas lasers. Semiconductor Laser, Band diagram, Pumping mechanism, Operation. Examples of nonlinear optical materials [4L] Superconductors Superconductivity; Electrical & magnetic properties of superconducting materials, Zero resistance property, Meissner effect, A.C. resistance, BCS Theory (Qualitative), Josephson's junction, Engineering applications of superconducting materials. [5L] Dielectrics Definitions, The local field, The Clauius-Mossoti relation, Sources of polarizability, Dipolar polarizability, Debye equation and study of molecular structure, Electronic polarizability, Ionic polarizability (Brief), Measurement of dielectric constant, Electrets, Piezoelectricity, Ferroelectricity and comparison with piezoelectricity, Applications of ferroelectric materials. [5L] Mechanical Beheviour of Materials Bonding of solids, Crystal structure, Crystal imperfections, Estimation of theoretical strength, Introduction of stress and strain, Hooke's law, elasticity, plasticity, Fracture of materials, (Fracture, Fatigue, Creep), Strengthening mechanism, Composites. [6L]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Introduction to Modern Physics, H. S. Mani & G. K. Mehta 2. Solid State Electronic Devices, B. G. Streetman 3. Solid State Physics, S. O. Pillai **REFERENCE BOOKS:** 1. Introduction to Solid State Physics, C. Kittel 2. Introduction to Materials Science for Engineers, J. F. Shackelford & M. K. Muralidhara 3. Electronic Properties of Metals, E. Hamuel

<table>
<tr><td colspan="9">Department of Physics</td></tr>
<tr><td colspan="9">Offered for Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
</table>

PHS383	Physics of Engineering Materials Laboratory	PCR	**0**	**0**	**3**	**3**	**2**

Course Outcomes	CO1: To realize and apply different techniques for measuring characteristics of p-n junction and application of Zener diode as voltage regulator. CO2: To determine the properties (carrier concentration and type) of semiconductor by Hall-effect experiments. CO3: To apply the knowledge to determine the properties (bandgap and resistivity) of semiconductor materials by four-probe method at different temperatures. CO4: To determine the characteristics of solar cell. CO5: To determine the physical parameter such as e/m of an electron and Stefan's constant.
Topics Covered	1. Determination of Stefan's constant. 2. Study of Hall voltage and Hall coefficient of a given material. 3. Measurement of electrical conductivity of a semiconductor. 4. To determine the energy bandgap of a semiconductor. 5. To study the variation of thermo emf of a thermo-couple with temperature and determine its thermo-electric power. 6. Determination of power conversion efficiency of a solar cell. 7. To study the quantization of energy (Frank Hertz Experiment). 8. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnet.
Text Books, and/or reference material	Suggested Books: A Text Book on Practical Physics – K. G. Majumdar. Practical Physics – Worsnop and Flint

FOURTH SEMESTER

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC401	**Design of Machine Elements**	PCR	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 301 (Solid Mechanics)		CT+EA					

Course Outcomes	CO1 Acquire an idea about engineering materials in machine design CO2 To learn the basic design procedure for different elementary machine elements CO3 To learn about design of bolt and welded joints, pressure vessels etc. CO4 Introduction to fatigue design
Topics Covered	Review of stress analysis, Theories of failure, Machine Design in continuation of strength of materials. 5 Fundamentals of machine design - General Principles and Procedures of design of machine elements, Factor of safety and Service Factor Mechanical properties of Engineering Materials 3 Design under Static load: C-frames and Crane hooks 4 Design under variable loading and Impact loading 5 Design of Shaft under Torsion, Bending, Axial load and Combined loads, Design of Shafts under fatigue load.10 Design of Keys, Splines, Rigid and flexible couplings 5 Design of Bolted joints 4 Design of Welded joints 4 Analysis and Design of thick cylinders and pressure vessels 5 Springs: Stress analysis and Design of Helical and Leaf springs. 4 Design of Connecting rods. 3
Text Books, and/or reference material	**Text Books:** 1. Mechanical Engineering Design – J.E. Shigley 2. Design of Machine Elements – M.F. Spotts 3. Design of Machine Elements – V.B. Bhandari
	Reference Books: Machine Design – Black and Adams

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 402	**Casting, Forming and Welding**	PCR	**3**	**1**	**0**	**4**	**4**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	CO1. Learn different types of casting process. CO2. Select suitable manufacturing process for typical components. CO3. Learn the various welding process. CO4. Explain the concept of forging, rolling process and drawing.
Topics Covered	**<u>Casting</u>** (20 hrs) Foundry: foundry materials- moulding and core sand- binders – additives; sand preparation- sand control tests 2 pattern and pattern making 3 mould and core making, expendable and non-expendable moulds, 3 mould assembly; solidification of pure metals and alloys, grain growth. 1 Casting processes- sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, centrifugal casting; continuous casting 5 casting design, gateway system design, riser design 3 casting defects- inspection, testing- destructive and non-destructive. 3 **<u>Welding</u>** (18 hrs) Metal joining- classification, welding heat sources, 1 arc welding machines, arc production, arc characteristics, metal transfer, welding electrode, 5 resistance welding, thermit welding, soldering and brazing, 2 gas welding, 3 Welding metallurgy, weldability of ferrous and nonferrous metals, 1 Welding defects , testing of welded joints 3 Other nonconventional welding methods like, ultrasonic welding, electron beam welding, laser beam welding etc. 3 **<u>Forming</u>**(18 hrs) Metal forming- cold, warm and hot working. Forging: processes and its classification- drop forging and press forging, open die, impression die, closed die and precision forging processes. grain flow in a forged product, 4 Specific forging operations like, coining, piercing, hubbing, heading, Swaging, roll forging, orbital forging, incremental and isothermal forging. 2 Forging defects. 1 Rolling: Strip rolling- recrystallisation and process details, Rolling mills, ring rolling, gear and thread rolling, various rolled sections, defects in rolled products. 5 Drawing: drawing terms and their definitions, circular drawing die, rod and wire and tube drawing. 4 Extrusion: processes- direct and indirect extrusion, impact and hydrostatic extrusion, metal extrusion practice, metal flow during extrusion. 2

Text Books, and/or reference material	**Text Books:** 1. Manufacturing Processes for Engg. Materials - Kalpakjian 2. Production Technology (vol I & II)—R. K. Jain and S.C. Gupta 3. Manufacturing Processes: H. S. Shan, Vol. 1 4. A textbook of Production Technology – P. C. Sharma
	Reference Books: 1. Manufacturing Science-- A. Ghosh, A.K.Mallik 2. Principles of Foundry Technology-- P.L.Jain

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 403	**Heat and Mass Transfer**	PCR	**3**	**0**	**0**	**3**	**3**
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
MEC 304 (Engineering Thermodynamics)			CT+EA				
Course Outcomes	CO1 Relation of thermodynamics and heat transfer CO2 Knowledge of Conduction mode of heat transfer CO3 Knowledge of Convection mode of heat transfer CO4 Knowledge of radiation mode of heat transfer CO5 Heat and mass transfer equipment's						
Topics Covered	Introduction, basic concepts and modes; relationship to thermodynamics. 1 Conduction: Mechanism; Fourier law of heat conduction in 3-D, 1-D steady state conduction with heat generation, composite plane wall, cylinders and spheres, thermal resistance network. Critical thickness of insulation; Use of analytical, numerical and graphical methods, thermal diffusivity, Fourier number, Heat Transfer from extended surface 12 Conservation principles: various conservation equations, Relation between system and control volume approach: Reynolds Transport Theorem, Entropy generation minimization as a general heat transfer objective, Basic convective configurations, Fluid flow and heat transfer aspect of internal flow, Fluid flow and heat transfer aspect of external flow, Visualization of convection, Flow over a flat plate, Concept of thermal and hydrodynamic boundary layers, Laminar and turbulent boundary layers, Scaling analysis, Natural, forced, mixed and turbulent convection, Dimensional analysis in correlations for convective heat transfer, Relation between fluid friction and heat transfer, Analysis of heat exchanger: LMTD, effectiveness-NTU method, Boiling and condensation mechanisms, Discrimination between diffusive and convective mass transfer, Fick's law of diffusion. 16 Radiation: physical mechanism, radiation properties, black body radiation, grey body, spectral dependence of radiation properties, Wien's displacement law, Kirchoff's law. Shape factor, heat exchange between infinite parallel planes, and Gray bodies; radiation shields, network representation. 7 Mass Transfer: Diffusive and Convective mass transfer, Evaporation process in the atmosphere, Fick's law and its applications. 6						

Text Books, and/or reference material	**Text Books:** 1. Heat Transfer-- J. P. Holman 2. Principles of Heat and Mass Transfer—F. P. Incropera, D. P. DeWitt, T.L. Bergan 3. A Heat Transfer Text Book, Dover - John H. Lienhard V, John H. Lienhard IV
	Reference Books: 1. Heat and Mass Transfer- Y. A. Cengel, A.J. Ghajar

Department of Electrical Engineering								
OFFERED FOR ME DEPARTMENT								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
EEC432	**Electrical Machines**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
EEC01(ELECTRICAL TECHNOLOGY)		CE+EA					
Course Outcomes	CO1: Theory of electromechanical energy conversion, the concepts of voltage generation and fundamental torque equation. CO2: Basic understanding of the principles of operation and construction of direct and alternating current machines and transformers. CO3: A study of theory and concept of Electric Machines (AC & DC). CO4: Deriving equivalent circuit of electrical machines. CO5: Studying the performance and characteristics of Electrical machines (AC & DC).						
Topics Covered	Basic principle of Faraday's law of electro-magnetic induction, energy conversion and magnetic circuit. (4) Transformer: Construction and principle of operation of single phase transformer, Step-up and Step-down transformer, E.M.F. equation, Equivalent circuits, phasor diagram, Open circuit and short circuit tests, losses and efficiency, All day efficiency, Auto transformer. (8) D.C. Machines Construction, Methods of excitation and classifications, Simple lap and wave windings, emf equation, characteristics of different dc generator, armature reaction, Commutation, Back e.m.f in a d.c. motor, Motor Starter, Speed and torque equations, Speed vs torque characteristics and speed control of DC motors, losses in dc machines, Applications. (12)						
	Induction Motor: Pulsating and rotating magnetic field construction and principle of operation of Single and three phase induction motors, cage and wound rotor induction motors, comparison between them slip, equivalent circuits, No load and blocked rotor tests, Circle diagram, Torque/speed curve Starting and speed control, Applications of single phase and three phase induction motors. (12)						

	Synchronous Machines: Construction-alternators-turbo & hydro generators, principle of operation, emf equation, excitation control, synchronization load sharing synchronous motor operation, Synchronous condenser, applications of synchronous generator and motor. (6)
Text Books, and/or reference material	Text Books: 1. Electrical Machinery by P S Bimbhra 2. Electrical Technology Vol-II by B L Thereza Reference Books: 1. Electrical Machines by J B Gupta

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES451	**Solid Mechanics Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics, Solid Mechanics		CT+EA					
Course Outcomes	CO1: Graphical and experimental verification of the solid Mechanics and Engineering mechanics						
Topics Covered	Mohr's Circle on strain Rosette- Graphical Solution. Mohr's Circle on Moment of Inertia - Graphical Solution. Mechanical testing of Engineering Materials. Experiments on the principles of strength of materials. Instrumentation for measurement of deflection under loading.						
Text Books, and/or reference material	**Text Books:** 1. Strength of Materials – A. Pytel and F. L. Singer **Reference Books:** 1. Elements of Strength of Materials – S. P. Timoshenko and D. H. Young 2. Strength of Materials – S. S. Rattan						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES452	**Fluid Mechanics Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC303 (Fluid Mechanics)		CT+EA					
Course Outcomes	CO1: Fundamentals of fluid mechanics.						

Topics Covered	Calibration of Venturimeter. Calibration of Orificemeter Determination of friction factor in flow through pipes. Determination of coefficient of bend loss in flow through pipes. Experiment on Impact of jet. Calibration of V-notch. Experiment on Bernoullie's Theorem.
Text Books, and/or reference material	**Text Books:** 1. Mechanics of Fluids: Massey, B. S. 2. Fluid Mechanics – J. F. Douglas, J. M. Gasiorek, J. A. Swaffied, L. B. Jack 3. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, *et a*l. 4. Hydraulic Machinery - Jagdish Lal
	Reference Books: Fluid Mechanics—F. M. White

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 453	**Mechanism Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics		CT+EA					

Course Outcomes	CO1: Students will be able to solve kinematics of mechanism by graphical method CO2: Students will be able to analyze mechanism by computer aided tools CO3: Students will be able to solve mechanism synthesis problems using computer aided tools CO4: Students will be able to demonstrate model of few planar mechanisms
Topics Covered	Determination of velocity and acceleration of various mechanisms by semi graphical methods. Analysis of inertia forces. Computer Aided Kinematic Analysis of planar mechanisms Computer Aided Mechanism Synthesis of planar mechanisms Modeling & simulation of mechanisms using Computer Aided Tools Model making
Text Books, and/or reference material	**Text Books:** 1. Theory of machines and mechanisms – Uicker, Penrock and Shigley 2. Theory of mechanisms and machines ---Ghosh & Mallick 3. Theory of machines – S S Rattan
	Reference Books: 1. Theory of machines – Thomas Bevan 2. Introduction to the mechanics of machines – Morrison and Crossland

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td colspan="9">OFFERED FOR ME DEPARTMENT</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES482</td><td>Electrical Machines Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EES51(ELECTRICAL TECHNOLOGY LAB), EEC432 (ELECTRICAL MACHINES)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Ability to determine the equivalent circuit parameters of a single-phase transformer
CO2: Ability to determine the parameters of single-phase as well as three phase induction motor.
CO3: Ability to determine the characteristics of dc shunt generator and series generator
CO4: Ability to control the speed of a dc shunt motor
CO5: Ability evaluate the voltage regulation of an alternator
CO6: Ability to determine the efficiency of dc machines</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
Determination of equivalent circuit parameters of a single-phase transformer.
2. No-load and load characteristics of a dc shunt generator.
3. Speed control of a dc shunt motor.
4. Open-circuit and load characteristics of a dc series generator.
5. Voltage regulation of an alternator.
6. To perform no-load and blocked-rotor tests on a three-phase Induction Motor.
7. To perform no-load and blocked-rotor tests on a single-phase Induction Motor.
8. Swinburne’s test of a dc machine.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc.
2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill.
Reference Books:
1. Laboratory manuals</td></tr>
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FIFTH SEMESTER

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 501</td><td>Machining and Machine Tools</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Knowledge of fundamental machining processes and the underlying sciences of machining and the related processes
CO2 Various machine tools, their operations and the mechanisms in machine tools</td></tr>
<tr><td rowspan="2">Topics Covered</td><td colspan="7"><u>Machining</u> (28 hrs)
Introduction to Manufacturing processes and Metal cutting, Types of basic motions, Speed, feed and depth of cut, Shapes produced by different combination of motions, representation of chip formation in 3D. 2
Cutting Tools: Single point, Multi point, Left hand and Right hand cutting tool. Single point cutting tool nomenclature and representation in 3D, Tool geometry in ASA and ORS systems, Effect of tool geometry on performance. 2
Experimental observations in metal cutting- chip thickness, width of cut, primary deformation zone, shear angle concept, Piispanen's model, types of chips and the conditions of their formation, strain hardening, heat generation and dissipation, cutting fluid. Orthogonal and Oblique cutting- 2D and 3D representation, effect on chip formation and on mechanics of chip formation. Concept of undeformed chip thickness, chip reduction coefficient determination- experimentally from chip length. Analytical determination of shear angle and shear strain from simple geometry of chip formation. 4
Forces in Metal cutting: Free body diagram and mechanics of chip formation, direction and Representation of forces on basic plane and orthogonal plane, 3D representation of forces on cutting tool, Merchant's Circle Diagram representation of forces, transformation of forces, kinematic coefficient of friction, total work done and its distribution, different specific energies, power estimation, Merchant's first shear angle relationship and its deviation from experimental observations. 4</td></tr>
<tr><td colspan="7">Tool life: Different way of tool failure, types of tool wear- their causes and remedies, features of flank and face wear, characteristic of wear growth, definition of tool life, factors affecting tool life, Taylor's tool life equation, effects of tool geometry on tool life. 4.</td></tr>
</table>

	Grinding- Machines and processes, Transverse grinding and plunge grinding, creep-feed grinding, centreless grinding, truing and dressing of grinding wheels, balancing of grinding wheels, Details of grinding wheels- Manufacturing and specifications, grinding wheel wear, grinding temperature. 6 Nonconventional machining processes: Working principles, processes and mechanics of process parameters and applications. ECM, EDM, AJM, USM 6
	Machine tools(28 hours) Fundamental of Machine tools, Machine tool elements. 1 General feature of construction and working of Lathe, Different parts of a Lathe, Types of Lathe and specification. Back gear arrangement, Work holding devices. Screw cutting, Taper turning, Form turning and various other operations performed by a Lathe. Feed, speed, depth of cut and machining time calculation. 6 General feature of construction and working of Drilling machine, Different parts of a Drilling machine, Types of Drilling machine and Specification. Reaming, Threading and various other operations performed by a Drilling machine. Types of Drill bits. Feed, speed and machining time calculation. 4 General feature of construction and working of Milling machine, Different parts of a Milling machine, Types of Milling machine and Specification. Dividing head and Indexing method. Up milling, Down milling, Spiral milling and other operations performed by a Milling machine. Types and choice of Milling cutter. Machining time calculation. 6 General feature of construction and working of Shaping machine and Slotting machine. Quick return mechanism. Whitworth mechanism, Feed mechanism. Types of tools. Machining time calculation. 4 Gear manufacture- milling, hobbing and shaping, Gear finishing processes 4 Turret and Capstan Lathe: Types, parts, equipments and tools for use on turret and capstan lathe, operational planning and turret tool layout. 4
Text Books, and/or reference material	**Text Books:** 1. Theory of metal cutting – G. Kuppuswamy 2. Production Engineering Sciences – Pandey and Singh 3. Manufacturing Processes – H. S. Shan, Vol. 2 4. A textbook of Production Engineering – P. C. Sharma
	Reference Books: 1. Manufacturing Science – A. Ghosh, A.K.Mallik 2. Theory of metal cutting – Sen and Bhattacharya

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC502	**IC Engine and Gas Turbines**	PCR	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 304, MEC 403		CT+EA					

Course Outcomes	CO1 Concept of internal combustion engines CO2 Mechanism of internal combustion engines CO3 Pollution from internal combustion engines CO4 Mechanism of gas turbines CO5 Outlines of alternative fuels
Topics Covered	Internal Combustion Engines: Basic engine types and their operation, construction and application. Engine design and operating parameters, thermo-chemistry of fuel air mixture, air-fuel cycle, properties of working fluids. Indicator diagrams, engine performance and output, compression ratio, air-fuel ratio, Ignition timing and other affecting variables on engine performance. Fuel and fuel rating. Charge motion within the cylinder, combustions in SI and CI engines. Detonation and Knock, Combustion chamber, Carburation and fuel injection systems. Scavenging, natural aspiration, turbo charging and super charging, Engine friction, lubrication and cooling. Operating variables Affecting SI and CI engine performance. Modern systems for controlling engine operation. Testing of IC engines. 27 Pollution from I. C. Engines and its control: Exhaust of IC engines, Composition of exhaust gases, Apparatus for exhaust gas analysis, Permissible limits and Remedial measures for control emissions. 5 Alternative fuels for I. C. Engines. 4 Gas Turbines: Application of gas turbines, analysis of open and closed cycles, Gas turbine combustion chamber. Single and multi-shell arrangements. Inter-cooling. Reheat and regeneration. Matching of turbine and compressor. Performance characteristics. Jet propulsion and application. 6
Text Books, and/or reference material	**Text Books:** 1. Internal Combustion Engine – V Ganesan 2. A text book of Internal Combustion Engines—R. K. Rajput **Reference Books:** 1. I. C. Engines-- P. W. Gill, Smith, Zury 2. I. C. Engine Fundamentals -- Obert 3. I. C. Engine Fundamentals –Heywood

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC503	**Machine Design**	PCR	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 302 (Theory of Machines and Mechanisms), MEC 401 (Design of Machine Element)		CT+EA					

Course Outcomes	CO1 Detail analysis of members under fatigue loads CO2 Design procedures for some machine elements used in mechanical drives CO3 Exposed to the importance of engineering tolerances and its use CO4 Introduction to different types of bearings and lubrications CO5 To understand the basics of gear mechanics
Topics Covered	Manufacturing considerations in Design: Fits and Tolerances. 4 Belt drives: Flat belts and V-belts. 5 Power screw 5 Bearings: Sliding contact bearing; Rolling contact bearings -Construction, Types and selection, Constructional details, Types of lubrication.7 Toothed Gear Drive: Spur gear- Contact forces, Materials, Static design by Lewis equation. 7 Dynamic loads on gears – Buckingham's method.Types, Terminology, Geometrical proportions, Analysis of contact, Materials, Analysis of Force, and Design of Helical, Bevel and Worm gears. Check for dynamicload and wear strength. Design of gear boxes.15 Brakes: Band brakes and Shoe brakes 5 Clutch: Friction clutches and Jaw clutches. 4
Text Books, and/or reference material	**Text Books:** 1. Mechanical Engineering Design – J.E. Shigley 2. Design of Machine Elements – M.F. Spotts 3. Design of Machine Elements – V.B. Bhandari
	Reference Books: 1. Machine Design – Black and Adams

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 504	**Dynamics of Machinery**	PCR	**2**	**1**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 302 (Theory of Machines and Mechanisms)		CT+EA					
Course Outcomes	CO1 Knowledge of gyroscopic motion of dynamic mechanical system CO2 Knowledge of balancing of rotating and reciprocating machines CO3 Knowledge of longitudinal, torsional and transverse vibration of mechanical system						

Topics Covered	Gyroscope Spinning, precession and gyroscopic couple; gyroscopic effect on ships and aeroplane; Application of Gyroscope 14 Balancing Internal and external balancing; Balancing of rotating masses -single plane balancing and two plane balancing, Balancing of reciprocating masses – single cylinder engine, Vee cylinder engine, and multicylinder inline engine.14 Vibration Longitudinal vibration – free vibration, damped vibration, and forced damped vibration; Torsional vibration – free vibration of rotor system and torsionally equivalent shaft; Transverse vibration – vibration of shaft carrying uniformly distributed load and several concentrated load, and critical speed of shaft. 14
Text Books, and/or reference material	**Text Books:** 1. Theory of Machines and Mechanisms, Uicker J.J., Pennock G 2. Theory of Mechanisms and Machines, Ghosh A., Mallik A.K.
	Reference Books: 1. Dynamics of machinery : Holowenko, Alfred R

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 541	**Experimental Methods in Engineering**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1: Acquire an idea about basic concepts of engineering measurements CO2: To learn the basics of data analysis CO3: To learn the fundamentals of data acquisition. CO4: To learn the measurement techniques for electrical signals, pressure, temperature, flow, force, motion, vibration etc.						
Topics Covered	Basic concepts: Calibration, Standards, Dynamic Measurement, System response and Fourier Analysis 4 Data analysis: Error analysis, Uncertainty analysis, Statistical analysis, Curve fitting, Goodness of fit. 6 Measurement of electrical signals: Waveform measurements, Analog/digital meters, Amplifiers, Signal Conditioner, Oscilloscope, transducers 5 Measurements of physical variables: Pressure measurement 4 Flow measurement 6 Temperature measurement 4 Force/ torque/ strain measurement, motion and vibration measurement. 9 Data acquisition and processing: Signal conditioning, Data transmission, ADC and DAC 4						

Text Books, and/or reference material	**Text Books:** 1. Experimental Methods for Engineers – J. P. Holman
	Reference Books: 1. Instrumentation, measurements and experiments in Fluids by E. Rathakrishnan 2. Handbook of experimental fluid mechanics by Foss et al. 3. Measurement systems—application and design, Doebelin, E. O.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 551	**Design and Dynamics Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT))					
XEC01, MEC 302, MEC 401		CT					
Course Outcomes	CO1: Acquire basic idea about the machine component drawing, geometric profiles of gears and cams CO2: To understand the use of gyroscope and governors CO3: Understanding vibratory systems and mass balancing concept.						

Topics Covered	• Drawings of the followings.
	  ○ Assignment 1: Dimensioning concept and detail drawing of machine components. (3hrs x3)
	  ○ Assignment 2: Generation of geometric profiles of gears and cams. (3hrs x 2)
	• Motorized gyroscope – Study of gyroscopic effect and couple (3Hrs)
	• Governor - Determination of range sensitivity, effort etc., for Watts / Porter / Proell / Hartnell Governors. (3Hrs)
	• Single degree of freedom Spring Mass System – Determination of natural Frequency and verification of Laws of springs – Damping coefficient determination (3Hrs)
	• Experiment on rotor balancing (3 Hrs x2)						

Text Books, and/or reference material	**Text Books:** 1. Theory of Mechanisms and Machines, Ghosh, Mallik 2. Theory of Machines and Mechanisms, Uicker J.J., Pennock G.R., Shigley J.E.						
	Reference Books 1. Introduction to the mechanics of machines, Morrison J.L.M., Crossland B. 2. Dynamics of machinery : Holowenko, Alfred R						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 552	**Heat Transfer Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 304, MEC 403		CT+EA					
Course Outcomes	CO1: Fundamental concepts of Temperature measurement systems CO2: Test on heat transferring apparatus CO3: Knowledge on conduction heat transfer CO4: Knowledge on convection heat transfer CO3: Knowledge on Radiation heat transfer						
Topics Covered	Various types of temperature measuring and controlling instruments. Thermocouples, Thermostats etc. Fundamental concept and function of Multi-channel temperature indicator, Experiments on- Determination of forced convection heat transfer coefficient through pin fin for variable flow rates of fluid at different inlet temperature. Determination of LMTD and effectiveness for parallel and counterflow heat exchanger. Verification of the laws of radiation with the help of radiation laboratory unit. `						
Text Books, and/or reference material	**Text Books:** 1. Heat Transfer-- J. P. Holman 2. A Course in Heat and Mass Transfer-- S.Domkundwar 3. A Course in Internal Combustion Engines-- R. P. Sharma, M. L. Mathur 4. I. C. Engines-- P. W. Gill, Smith, Zury						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 553	**CAD/CAM Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 401		CT+EA					
Course Outcomes	CO1: Able to learn geometric modelling using CAD tools CO2: Able to use MATLAB for solving computer graphics problem and engineering analysis problem CO3: Exposed to CNC part programming						
Topics Covered	Solid Modeling using software packages Graphics programming using MATLAB CNC part programming for Tool path generation & verification using CAM software						

Text Books, and/or reference material	**Text Books:** 1. Mastering CAD/CAM by I.Zeid 2. Getting started with MATLAB by Rudra Pratap
	Reference Books: 1. Computer Graphics by Roy A Plastock

<table>
<tr><td colspan="9">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>WSS 581</td><td>Workshop Practice II</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Hands-on practice on Foundry
CO2: Hands-on practice on different job manufacturing in machine shop
CO3: Hands-on practice on Pattern Shop
CO4: Hands-on practice on welding Shop</td></tr>
<tr><td rowspan="2">Topics Covered</td><td colspan="7">Machine shop -- 3X6=18hrs.
● Mechanism and function of different parts of machine tool.
● Machining operations:
1) Machining of shaft and knurling by lathe.
2) Thread cutting by lathe.
3) Taper turning by lathe.
4) Machining of gear blank by lathe.
5) Making of Square Bar by shaper.
6) Machining of surface by shaper.
7) Spur gear cutting by milling.
● Introduction of two and three axis CNC m/cs.
● Explanation of ‘G’ and ‘M’ Codes.
● Introduction to non-conventional machining.
Welding shop -- 3X2= 6hrs.
● Welded joints- square butt joint & T-fillet joint by SMAW with mild steel flat.
● Types of electrodes and coding systems of electrodes.
● Types and functions of flux.
● Positions of welding, polarity in welding.</td></tr>
<tr><td colspan="7">Pattern shop -- 3X2= 6hrs.
● Description of wooden pattern.
● Types of pattern, pattern allowance.
● Layout and design of pattern making.</td></tr>
</table>

	Foundry -- **3X2= 6hrs.** ● Preparation of sand mould using Solid/Split Pattern. ● Aluminium casting using the prepared mould. ● Determination of properties of Green Moulding Sand using Sand Testing Equipments. **Viva voce** -- **1X3= 3hrs.**
Text Books, and/or reference material	**Text Books: Reference Books:** 1. Manufacturing Science-- A. Ghosh, A.K.Mallik 2. Principles of Foundry Technology-- P.L.Jain

SIXTH SEMESTER

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSC 631</td><td>Principles of Economics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 304 Engineering Thermodynamics, MEC 403 Heat and Mass Transfer</td><td colspan="7">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: To review basic economic principles with students;
CO2: To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works;
CO3: To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Group A: Microeconomics
Economics: Basic Concepts 3
Theory of Consumer Behaviour 3
Theory of Production, Cost and Firms 3
Analyses of Market Structures: Perfect Competition 3
Monopoly Market 3
General Equilibrium 3
Welfare Economics 3
Group B: Macroeconomics
Introduction to Macroeconomic Theory 3
National Income Accounting 3
Determination of Equilibrium Level of Income 3
Money, Interest and Income 3
Inflation 3
Unemployment 3
Multiplier 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="8">Group A: Microeconomics
1. Koutsoyiannis: Modern Microeconomics
2. Maddala and Miller: Microeconomics
3. AnindyaSen: Microeconomics: Theory and Applications
4. Pindyck&Rubenfeld: Microeconomics</td></tr>
<tr><td colspan="8">Group B: Microeconomics
1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed)
2. N. G. Mankiw: Macroeconomics, Worth Publishers
3. Dornbush and Fisher: Macroeconomic Theory
4. SoumyenSikder: Principles of Macroeconomics</td></tr>
</table>

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit	
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours		
MEC601	**Power Plant Engineering**	PCR	**2**	**1**	**0**	**3**	**3**	
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))						
MEC 304 Engineering Thermodynamics, MEC 403 Heat and Mass Transfer		CT+EA						
Course Outcomes	CO1 Study of power production CO2 Study of some power plant related equipment's							
Topics Covered	Primary and Secondary sources of energy, Global trend for per capita consumption of energy, Demand of energy and future availability in usable form. Recent developments in renovation of energy sources. 2 Analysis of steam cycles: Steam power plant outline, effect of steam condition on thermal efficiency, regenerative feed heating, feed water heaters, optimum degree of regeneration, deaerator, co-generation of power and process heat 9 Fuels and combustion: Coal- ranking and analysis, fuel oil, natural and petroleum gas, Combustion reactions 2 Combustion equipment's and firing methods: Fuel bed combustion, pulverized coal firing, Cyclone furnace, fluidized bed combustion-CFB and BFB, Coal gasifiers 7 Steam generator: High pressure boilers, Subcritical and Supercritical boilers, Calculation on economizer, Superheater, Reheater and Air preheater, Draught systems - FD, ID and balanced draught, calculation of fan power. Circulation-natural and Forced, circulation ratio, Performance rating of boilers. 8 Flow through nozzles and diffusers, Shocks, Super-saturation of steam through nozzle Flow. 3 Steam turbines: Machines working on impulse and reaction principles, Turbine blading, Velocity triangles, Blade speed ratio, Velocity and pressure compounding, Stage and overall efficiencies, Degree of reaction.8								
Text Books, and/or reference material	**Text Books:** 1. Power Plant Engineering-P.K.Nag 2. Power Plant Technology - M.M. El.Wakil 3. A Course in Power Plant Engineering- S. Domkundwar, S.C. Arora							
	Reference Books: 1. Power Plant Engineering- F.T. Morse 2. Steam Turbine Design and Practice- Kareton 3. Power Plant Engineering- Black and Veatch							

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 602	**Industrial Engineering and Measurement**	PCR	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic knowledge of Engineering Mechanics		CT+EA					
Course Outcomes	CO1: Knowledge on the structures of Engineering Organization in general. CO2: Planning of manning and production line. CO3: Ability for material management. CO4: Indian standards of measurement. CO5: Techniques of engineering measurements with its application.						

Topics Covered	Organization Structure: Classical principles, Different types of organization structure- Line, Staff, Line and staff, Committee organization, Case study. 3 Plant Location: Factors affecting plant location, Plant location theories- material index theory, location factor theory, Dimensional decision making model, Force analogy method, Specific site selection. 4 Plant layout: Different types of layout, Various flow patterns, Factory building construction, Travel chart. 2 Job evaluation, Merit rating and Wage incentive schemes: Methods of job evaluation- Ranking method, Classification method, Point method, Factor comparison method. Merit rating- Point rating scale, Employee comparison system. Different wage incentive schemes. 4 Work study: Operation process chart, Flow process chart, Flow diagram, String diagram, Multiple activity chart- Man-machine chart, Man-machine-helper chart, Left hand-right hand chart, Motion study, SIMO study, Cycle graph and chronocycle graph, Performance rating, Stop watch time study. 4 Production, planning and control: Routing and scheduling, Assignment problems- 2 machines and n jobs, 3 machines and n jobs, m machines and n jobs, n machines and n jobs, Gantt chart. 4 Generalised measurement systems- Calibration, Sensitivity, Damping, Characteristics of first order and second order systems, Dynamic response, Harmonic analysis. 5 Standards of linear measurements, Interferometric measurements. 2 Limit, Fit and Tolerances: Basis of a limit system, Unilateral and Bilateral systems. 2 Indian limit system IS 919:1993; Types of fits and selection of fits, IS 2709:1982 3 Dimension chain and Dimensional analysis, Design and use of limit gauges. 2 Error of flatness and straightness: Concept of mean true plane, Measurement of flatness error using Beam Comparator, Autocollimator and Precision Block Level. 3 Dynamometers for measuring 2-component and 3-component machining forces. 2 Surface roughness measurement. 3
Text Books, and/or reference material	**Text Books:** 1. Industrial Engineering and Management-- Dr. Ravishankar 2. Industrial Engineering and Production Management-- M. Mahajan 3. A Text book of Engineering Metrology-- I.C.Gupta 4. Engineering Dimentional Metrology-- L.Miller
	Reference Books: 1. Management in Industry-- C.S.George 2. Engineering Tolerences-- H.W.Conway

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEE 610	**Automobile Engineering**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 304, MEC403, MEC 502		CT+EA					
Course Outcomes	CO1: Classification and layouts of different vehicles CO2: Different types of Engines in use CO3: Different types of clutch, gear box and transmission used CO4: Different types of brakes, drivelines and wheels and tyres.						
Topics Covered	Automotive engine: Construction, operation and service of automotive engine. 8 Bearing, lubrication and cooling system. Fuel and exhaust, emission control. 6 Starting and charging system. Contact point and electronic ignition system. Other accessories with electrical and electronic devices. Engine trouble diagnosis and tune up. 10 Automotive power train: Transmission and transaxles, gear train, differentials and drive axles, drive lines and universal joints, clutches and brakes. 8 Automotive chassis: Springs and suspension system, steering system, wheels and tyres. 6 Automotive ventilation and air conditioning techniques. 4						
Text Books, and/or reference material	Suggested Text Books: 1. Automobile Engineering-- K. Singh 2. Automotive mechanics-- W. H. Crouse, D. L. Anglin Suggested Reference Books: 1. Automotive mechanics-- J. Heitner						

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 611</td><td>Gas Dynamics and Propulsion</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">MEC303 (Fluid Mechanics) and MEC304 (Thermodynamics)</td><td colspan="5">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn compressible flows with constant entropy only, with friction only and with heat transfer only.
CO2: To learn Normal shock, oblique Shock and Prandtl-Meyer Flow with real life applications.
CO3: To learn Performance analysis ofAir Breathing Engines (Ramjet, Turbojet (standard): Fan exhausted turbojet & Fan mixed turbojet and Turbo prop.)
CO4: To learn Performance analysis of Non Air Breathing Engines (Solid Rocket Motors and Liquid Rocket Engines).</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Part-I: Gas Dynamics:</u>
Review of basic compressible flow e.g. sonic velocity, wave propagation. Flow with Variable area duct without normal shock and with normal shock. Fanno flow and Rayleigh flow. Solution of problems using gas table.7
Moving Normal shocks and Oblique shocks: Normal velocity superposition for moving Normal shock and tangential velocity superposition for oblique shock, oblique shock analysis for perfect gas, oblique shock table and charts. Problems. 7
Prandtl-Meyer flow: Isentropic turn (either around expansion or compression corner) from infinitesimal shocks, Mach waves, Prandtl-Meyer flow analysis, Prandtl-Meyer function, over-expanded and under-expanded nozzles, boundary conditions for flow direction and pressure, shock diamond, supersonic aerofoils, Working of supersonic wind tunnel. 4
Correlation of Fanno flow, Rayleigh flow, and a normal shock 2
<u>Part-II: JET PROPULSION</u>
Air Breathing Engines: Derivation of generalized equation/ expressions for thrust, propulsion efficiency, thermal efficiency and overall efficiency. Relation between them, TSFC(Thrust specific fuel consumption); stoichiometry , equivalence ratio, mass fraction, mole fraction, partial pressure, mass balance in chemical equations, heat of reaction, heat balance in constant volume and constant pressure processes, fuel air ratio, variation of temperature with F/O and its stoichiometric value. Condition for maximum efficiency.
Performance analysis of the following:</td></tr>
</table>

	(a) Ramjet, (b) Turbojet (standard): Fan exhausted turbojet & Fan mixed turbojet (c) Turbo prop. Effect of after burner on all the above. Related problems **12** **Non-air breathing engines:** Performance of Rocket vehicles such as Thrust, specific Impulse (I_{sp}),vehicle acceleration, burning time. Type of chemical Rockets: Solid Rocket Motors and Liquid Rocket Engines. Elementary theory and performance characteristics of both types of chemical rockets. Related problems.**10**
Text Books, and/or reference material	**Text Books:** 1. Fundamentals of gas dynamics -R.D. Zucker & Oscar Biblarz. 2. Mechanics and thermodynamics of propulsion: P. G. Hill & C.R. Peterson. **Reference Books:** 1. The Dynamics and Thermodynamics of Compressible Fluid Flow by A. H. Shapiro. 2. Aircraft Propulsion : V. Babu

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 612	**Mechanics of Forming and Press Working**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 402		CT+EA					
Course Outcomes	CO1: Detailed and in depth analysis of the forming processes. CO2: Specialized techniques in forming practiced in industry.						
Topics Covered	**Module 1:** **Stress-strain relationship:**true stress true strain, elasticity, anelasticity, plasticity, work hardening, work done or strain energy. Complex Stress System, concept of absolute maximum shearing stress in a plane-stress system, three dimensional stress system and Mohr's circle for the general state of stress (3-D). **Plastic Deformation and Yield Criteria:** maximum normal stress theory (Rankine's Theory), Tresca's maximum shear stress theory, Von Mises' maximum distortion energy theory, relation between tensile yield stress and shear yield stress, yielding under plane strain Graphical representation of Tresca's and Von Mises' theory. **Forging:** processes and its classification- drop forging and press forging, open die, impression die, closed die and precision forging processes. Grain flow in a forged product. Forging die materials, lubrication, forging defects, forgeability of metals, die-manufacturing methods. Analysis of forging load: Low friction or sliding friction condition (as in cold forming); high friction condition; and, combined slipping and sticking friction condition.						

	Rolling: strip rolling- recrystallization and process details, conditions for biting, role of friction in rolling. Rolling mills, ring rolling, gear and thread rolling, various rolled sections, defects in rolled products. Determination of roll pressure: pressure distribution in rolling, determination of neutral point, front tension and back tension, force and power calculation. Roll deflections and roll flattening, spreading, methods of reduction of rolling force, roll materials, various rolled sections. **Drawing:** drawing terms and their definitions, circular drawing die, drawing of wire and rod (homogeneous deformation), maximum possible reduction in a single pass, analysis of strip drawing, calculation of force and power, analysis of wire and rod drawing, calculation of force and power. **Extrusion:** processes- direct and indirect extrusion, impact and hydrostatic extrusion, metal extrusion practice, metal flow during extrusion. **<u>Module 2:</u>** **Sheet metal forming:** characteristics; parameters affecting sheet metal forming process such as, yield point elongation, anisotropy, grain size, residual stresses, spring back, wrinkling, coated sheet. 1 **Shearing, punching and blanking:** punch force; shearing operations like, die cutting, fine blanking, slitting, steel rules, nibbling; Shearing dies: Punch and die shapes, compound dies, progressive dies, transfer dies, tool and die materials. 5 **Bending of sheets and plates:** minimum bend radius, factors affecting bendability, spring back, compensation for spring back, common bending operations. 3 **Deep drawing:** Characteristics of deep drawing, formability of sheet metal, design considerations **Miscellaneous forming processes:** stretch forming, bulging, hydroforming, various spinning operations. 3 **High energy rate forming:** Explosive forming, electrohydraulic forming, magnetic pulse forming, superplastic forming etc. 3
Text Books, and/or reference material	**Text Books:** 1. Manufacturing Processes for Engg. Materials - Kalpakjian 2. Production Technology (vol I & II)—R. K. Jain and S.C. Gupta 3. Manufacturing Processes: H. S. Shan, Vol. 1 4. A textbook of Production Engineering – P. C. Sharma
	Reference Books: 1) Manufacturing Science-- A. Ghosh, A.K.Mallik

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 613	**Advanced Solids Mechanics**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

MEC301 (Strength of Material)	CT+EA
Course Outcomes	CO1: Three dimensional stress and strain analysis. CO2: Development of solution procedures using energy method CO3: Analysis of non-circular shafts and thick cylinders.
Topics Covered	Mathematical preliminaries: Vector, Matrix, Index notation. 4 Analysis of stress: Three dimensional state of stresses, Equation of equilibrium in cartesian and cylindrical coordinate system and equality of cross shear, plane state of stress, Principal stresses, Stress Invariants, Mohr's circles, Mohr's stress plane, Octahedral stresses. 10 Analysis of strain: State of strain, Green-Lagrange and infinitesimal strain in cartesian and cylindrical coordinate system, Principal strain, Compatibility conditions, Airy's stress function. 10 Energy methods: Elastic strain-energy for axial force, shear force, bending moment and torque, Theorem of virtual work and its application to derive governing equation of beam, Castigliano's theorems. 10 Torsion of non-circular bar: Torsion of circular and elliptical bars, Torsion of rectangular bars. 8 Thick cylinders: Axisymmetric problems, Thick cylinder subjected to internal and external pressure, Composite cylinder. 6
Text Books, and/or reference material	Suggested Text Books: 1. Theory of elasticity By Timoshenko and Goodier (Mc Graw Hill) 2. Advanced Mechanics of Solids by L. S. Srinath Suggested Reference Books: 3. Elasticity theory, applications and numerics by M. H. Sadd (Academic Press) 4. Advanced mechanics of solids By O. T. Bruhns (Springer) 5. A treaties on the mathematical theory of elasticity A. E. H. Love (Dover Publications)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 614	**Advanced Machining and CNC Machine Tools**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 402		CT+EA					

Course Outcomes	CO1: To understand theory of machining, orthogonal cutting CO2: To understand oblique cutting mechanics as applied to drilling and milling CO3: To study other important aspects in machining related to cutting tools CO4: Able to understand the fundamentals of CNC machine tools, Part programming, and Part programming languages
Topics Covered	**Module 1 : Advanced Machining (21 hours)** Introduction: Characteristics and development of tool materials, cutting tool inserts and its geometry, cutting fluids 3 Mechanics of Metal Cutting, Shear angle relationships and Lee and Shaffer's Theory, Work hardening and Chip breakers. 3 Stress distribution on rake face of the tool 1 Thermal aspects of machining. 2 Mechanisms of tool wear, Surface Finish and Effects of cutting parameters and tool geometry on tool life. 4 Economics of machining. 1 Drilling: Geometry of drilling tools and mechanics of drilling. 3 Milling: Geometry of milling tools and mechanics of plain milling 4 **Module 2 : CNC Machine Tools 21** CNC machine tools, constructional features, 2 Drives and controls, stepper motors, servo motors, hydraulic systems, 4 Feed back devices, 1 Counting devices, 1 Interpolators- linear, circular interpolation and other emerging techniques, 2 CNC part programming, post processors, 5 CNC programming with interactive graphics, 4 Use of various software packages, 2
Text Books, and/or reference material	**Text Books:** 1. Theory of metal cutting – G. Kuppuswamy 2. Production Engineering Sciences – Pandey and Singh 3. A textbook of Production Engineering – P. C. Sharma 4. Computer Aided Manufacturing :P Rao, N Tewari, T.K. Kundra
	Reference Books: 1. Manufacturing Science – A. Ghosh, A.K.Mallik 2. Theory of metal cutting – Sen and Bhattacharya 3. Computer numerical control of machine tools: G. E. Thyer

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 615	**Operations Research**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	CO1: Students will be able to discuss the history, concepts, formulations and applications of operations research. CO2: Students will be able to analyze and solve conflicting problems on constrained linear optimization problems having single and multiple objectives. CO3: Students will be able to apply integer, dynamic programming methods for solving relevant problems.
Topics Covered	Origin, growth, definition, methodology and application of OR. 2 Linear Programming, Mathematical Modelling, Graphical Method of Solution, Sensitivity Analysis. 8 Simplex Method, Big M and 2-Phase Methods, Duality in LP. 7 Transportation problem. 3 Assignment Problem 3 Sequencing problem. 2 Queuing model and Simulation. 3 Competitive Decision Making, Game Theory. 4 Duality Theory and Sensitivity Analysis. 3 Integer Programming, Binary Integer Programming. 4 Dynamic Programming. 3
Text Books, and/or reference material	**Text Books:** **1.** Hillier, Fredrick S. and Lieberman, Gerald J., Introduction to Operations Research, 7th Edition, TMH, 2001. **2.** Basu, S. K., Pal, D. K., Bagchi, H., Operation Research for Engineers, 2nd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., 1998 **3.** Taha, H. A., Operation Research, McMillan Publishing Co., London, 1982.
	Reference Books: **1.** Churchman, C. M., Ackoff, R. L., Arnoff, E.L., Introduction to Operation Research, Asia Publishing o., 1962 **2.** Hanssmann, F., Operations Research in Production and Inventory Control, John Wiley & Sons, Inc., London, 1962.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 616	**Mechanical Equipment Design**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 401 - Design of Machine Elements & MEC 503 - Machine Design		CT+EA					
Course Outcomes	CO1: Exposure to various types of mechanical elements and their design procedure. CO2: Ability to design different mechanical systems independently. CO3: Understand the working of various types of drive systems. CO4: Dealing with the case studies help develop self-confidence.						
Topics Covered	Chain Drive 4 Rope Drive 4 Spiral Bevel Gear Drive 4 CVT Mechanism 4 Design of Pulley and Idlers 5 Design of Worm Gears 4 Cam Mechanisms 4 Disc Brakes 4 Selection of Single-Phase Induction Motors 3 Case Studies 6						
Text Books, and/or reference material	**Text Books:** 1. Black and Adams, Machine Design, McGraw Hill Book Company Private Ltd., USA, 1973. 2. 2. Phelan R.M., Fundamentals of Mechanical Design, TMH, 2015.						
	Reference Books: 1. Burr, Arthur H., and Cheatham, John B., Mechanical Analysis and Design, Prentice Hall, USA,1995 2. Norton, R.L. , Machine Design: An Integrated Approach						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 620	**Advanced Foundry Engineering**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MEC402 (Casting, Forming and Welding)	CT+EA

Course Outcomes	• CO1 At the end of the course student will be able to get the knowledge about various aspects of casting processes and the underlying science • CO2 : various types of casting methods • CO3 : Application fields of various casting processes
Topics Covered	**Casting Processes:** Classification, characteristics of sand casting processes, metal mould casting process, Pattern materials, types of patterns, Mould and core making materials and their characteristics. (12) **Solidification of metals**: Nucleation and grain growth, solidification of pure metals, short and long freezing range alloys, Rate of solidification, macrostructure and microstructure. Solidification Contraction, Grain refinement (6) **Sand Casting Design**: Gating and risering design calculations, Fluidity and its measurement. (6) Investment casting, shell moulding, squeeze casting, vacuum casting, counter-gravity flow-pressure casting, Directional and monocrystal solidification, squeeze casting, semisolid metal casting, rheocasting. (8) Family of cast iron – Ductile Iron, Malleable Cast Iron, (3) **Casting defects**- inspection and testing , analysis of casting defects, nondestructive testing of casting- dye penetrant testing, magnetic flaw detection, radiography, ultrasonic testing, etc. (4) **Near net shape casting processes**, Modern foundry practices and special casting method. Continuous casting (3)
Text Books, and/or reference material	**Text Books**: 1. John Campbell, "Casting Practice" Elsevier Science Publishing Co.,2004 2. Scrope Kalpakjian, "Manufacturing processes for Engineering Materials",Addision, Wesley, 1997. 3. P.C. Mukherjee, Fundamentals of metal casting technology - Oxford and IBH 4. Beely, Foundry Technology, Newnes-Butterworths, 1979 **Reference Books**: 1. Casting properties of metals and alloys -V. Korolkove. 2. ASM Hand Book "Casting", ASM International 1998.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 621	**Mechanics of Composite and Functionally Graded Materials**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))

Engineering Mechanics, Strength of Materials	CT+EA
Course Outcomes	CO1:Concept of orthotropic materials CO2:Analysis of composite structures CO3:Concept of FGM
Topics Covered	Composites, various reinforcement and matrix materials. 3 Concept of orthotropic, transversely isotropic material, stress-strain relation for orthotropic and transversely isotropic material. Engineering constants for these materials. Transformation of stress and strain. 8 Micromechanical behavior of lamina. 6 Macro mechanical behavior of lamina, Classical lamination theory, Laminate stiffness of a few cases, Stress strain variation in a laminate. 8 Equation of equilibrium for laminated plates for bending, Solution technique for bending of simply supported laminated plates under uniformly distribute transverse load. 8 Failure criterion of composites. 4 Introduction to FGM. 5
Text Books, and/or reference material	**Text Books:** 1. Mechanics of composite materials By R. M. Jones (Taylor and Francis) 2. Engineering mechanics of composite materials By I. M. Daniel , O. Ishai (OxfordUniversity Press)
	Reference Books: 1. Mechanics of laminated composites plates and shells By J. N. Reddy (CRC Press) 2. The behavior of structures composed of composite materials By Jack R. Vinson and Robert L. Sierakowski

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 622	**Engineering Optimization**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Students will be able to describe and formulate optimization problems CO2: Students will be able to apply knowledge of different optimization methods for solving engineering problems CO3: Students will be able to differentiate between optimization methods and suggest a suitable technique applicable for a specific problem.						

Topics Covered	Introduction: Engineering Application, Statement and Classification of the Optimization Problem, Classification, formulation procedures. 4 Classical Methods: Single Variable Optimization; Multivariable Optimization without any Constraints with Equality and Inequality Constraints, Kuhn–Tucker Conditions; Linear Optimization Methods, One-Dimensional Minimization Method. Unimodal Function. 6 Elimination Methods: Exhaustive search, Fibonocci and Golden Method. 3 Interpolation Method – Quadratic and Cubic Interpolation Method. 2 Unconstrained Minimization Method -- Univariate, Conjugate Directions, Steepest Descent (Cauchy) Method, Newton's Method, Marquardt Method, Quasi-Newton Method. 6 Constrained Minimization Method, Random Search Methods, Sequential Quadratic Programming. Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Exterior Penalty Function Method. 5 Non-traditional Optimization Techniques - Genetic Algorithms. Simulated annealing. Particle swarm optimization. Ant Colony Optimization. Tabu search. 11 Reduction of size of an optimization problem. Scaling of design variables and constraints. 3 Introduction to optimization Toolbox in MATLAB. 2
Text Books, and/or reference material	**Text Books:** 1. S.S. Rao, Engineering Optimization, Theory and Practics, 3rd Enlarged Edition, New Age International Publishers, New Delhi, 2010. 2. Ashok D. Belegundu and Tirupathi R Chandrupatla, Optimization Concepts and Applications in Engineering, Pearson Education 1999, First India Reprint, 2002.
	Reference Books: 1. G. N. Vanderplaats, Numerical Optimization Techniques for Engineering Design with Applications, McGraw-Hill, New York, 1984. 2. R. L. Fox, Optimization Methods for Engineering Design, Addison- Wesley, Reading, Mass, 1971.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 623	**Multi Phase Flow and Heat Transfer**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC303, MEC403		CT+EA					

Course Outcomes	CO1: Leads students toward a clear understanding and firm grasp of the basic principles of multi phase flow and heat transfer. CO2: Understands the fluid-dynamic involved in convection and multi-phase heat transfer. CO3: Performs elementary analysis of most gas-liquid two-phase systems and prepares to use more advanced models. CO4: Equips the student with the analytical model to apply the fundamentals to a wide variety of complex engineering problems, formulate them and interpret the results. CO5: Student can analyze Hydrodynamics of three phase flows and compare two phase flow situations.
Topics Covered	Introduction, Flow Regimes, 5 Homogeneous Flow, Separated Flow 4 Condensation,2 One dimensional steady separated flow model,6 Flow in which inertia effects dominate, energy equations,3 The separated flow model for stratified and annular flow,2 General theory of drift flux model,3 Application of drift flux model to bubbly and slug flow, 4 Hydrodynamics of solid-liquid and gas-solid flow,4 An introduction to three phase flow,3 Fluid-Population Balance Technique, Volume of Fluid Method, Lattice Boltzmann Model.6
Text Books, and/or reference material	**Text Books:** 1. Ghiaasiaan, S. M., Two-Phase flow, Boiling, and Condensation, Cambridge University Press. 2. Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 3rd ed., Oxford University Press 3. Wallis, G.B., One Dimensional Two Phase Flow, McGraw Hill Higher Education. 4. Hewitt, G.F., Measurement of Two Phase Flow Parameters. 5. Govier, G.W., and Aziz, k., Flow of Complex Mixtures. 6. Hetsroni, G., Handbook of Multiphase systems.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 624	**Tribology**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 301, MEC 502, MEC 504		CT+EA					

Course Outcomes	CO1: To learn the basic knowledge of surface topography and contact between engineering surfaces. CO2: To learn the basic theory and application of friction and wear for different materials CO3: To learn about lubricants and lubrication for different bearings CO4: Introduced to Bio-tribology of human joints CO5: Introduced to Micro-tribology for MEMS applications
Topics Covered	**Surface topography:** Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. 3 **Contact between surfaces:** Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces. 6 **Friction and Wear of contact surfaces:** Laws and Theories of friction and wear; Friction and Wear of different materials; Application to friction materials. 12 **Lubricant and lubrication:** Viscosity of lubricants; Composition and properties of oils and greases; Reynolds equation; Type of lubrications - Hydrostatic lubrication, Hydrodynamic lubrication; Elasto hydrodynamic lubrication; Boundary lubrication, and application to bearings. 12 **Microtribology:** Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Applications to MEMS 7 **Biotribology:** Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication: Mechanism of articular cartilage damage; Artificial joint replacements 8
Text Books, and/or reference material	**Text Books:** 1. Engineering Tribology, Dr. Prasanta Sahoo 2. Introduction to Tribology of Bearings-- B.C.Majumder 3. Principles of Tribology-- J.Halling 4. Basic Lubrication Theory, Alastair Cameron

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 625	**Computer Aided Design and Manufacturing**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Machine Design, Engineering Mathematics, Machine Tool		CT+EA					
Course Outcomes	CO1: Able to understand scope and application of CAD/CAM tools in industry CO2: Able to learn geometric modelling and computer graphics concept in CAD tools CO3: Able to understand the different design analysis and optimization tools in CAD. CO4: Able to understand the fundamentals of Additive manufacturing, CNC machine tools, Part programming, FMS etc.						

Topics Covered	Introduction: Current trends in Design & Manufacturing, Fundamental concept of CAD-CAM-CAE, Product Life-cycle, Overview of CAD-CAM system. 3 Computer Graphics: Fundamentals of Geometric transformations, Graphics standards, CAD-CAM Data Exchange 4 Geometric Modeling: Basics of Wire-frame entities, curve representation methods Surface entities, Solid modeling & concepts of B-rep and CSG representation scheme 5 5Engineering Analysis Tools: Fundamentals of Finite Element Modeling (FEM), Introduction to design optimization tools. 8 Virtual Prototyping & Rapid Prototyping: Introduction to Virtual Prototyping and its applications in Mechanical Engineering, Principles & applications of Additive manufacturing technologies. 5 Industrial Robotics: Classification, definition of industrial robot, Robot anatomy, Configuration of robots, Application of robot, Robotic end-effector, Robot programming language. 3 CNC Machine tools & CNC Programming: Structure of CNC machine tool & functional units, Designation of axes, Drives & actuation systems, Feedback devices, Automatic tool changer, Part programming fundamentals, Computer Aided Part Programming, APT language structure, CAD interface. 7 Group Technology: Part family, part classification and coding, benefits of group technology 3 Introduction to FMS & CIM: Introduction to FMS, Components of FMS, Fundamentals of CAPP, Introduction to Computer Integrated Manufacturing. 4
Text Books, and/or reference material	**Text Books:** 1. CAD/CAM: Theory & Practice by I.Zeid 2. CAD/CAM by P.N.Rao 3. Principles of Computer-Aided Design and Manufacturing by Farid Amirouche 4. Computer Graphics by Roy A Plastock
	Reference Books: 1. Mastering CAD/CAM by I.Zeid 2. Robotics by Fu, Gonzalez, Lee 3. Finite Element Method by J.N.Reddy

<table>
<tr><td colspan="9">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 651</td><td>Engineering Measurement Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 501</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Workshop and precision engineering measurement methods.
CO2: Exposure to measuring instruments and their use.</td></tr>
</table>

Topics Covered	Use of different basic measuring instruments. Measurement of external and internal radius. Measurement of external and internal taper. Measurement of bore diameter. Measurement of chordal gear tooth thickness. Measurement of angle of an angle plate. Measurement of diameters of a screw thread. Measurement of error of surface roughness using Talysurf. Measurement of different thread elements using optical projector. Measurement of composite error of gears using Roll Gear Tester.
Text Books, and/or reference material	Hands out for each experiment. User manual for the instruments.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 652	**Power Generation Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 304, MEC 403, MEC 502		CT+EA					
Course Outcomes	CO1: Experimentation of refrigerating systems CO2: Experimentation on steam generators CO3: Study of steam turbines CO4: Test on diesel engine CO5: Experimentation on steam nozzle						
Topics Covered	Refrigeration and air-conditioning: Specification, performance test and loading of refrigerators. Concept of air conditioning. Types of air conditioning systems and their application. Steam generators: Fundamental concept, types, application and performance data. Use of steam for power generation. Fundamental concept and function of Turbines. *Study of-* Construction of fire tube and water tube boiler. Starting and loading of fire tube boiler. Construction of vapour compression refrigerator unit.						

	Experiments on- Determination of dryness fraction of steam. Efficiency test of a boiler. Performance test of diesel engine using mechanical type dynamometer under variable speed conditions. Determination of critical pressure ratio of a steam nozzle. Effect of humidity and outside air temperature on cooling load of air conditioning machine. Determination of output and back-work ratio of a gas turbine unit under variable load condition.
Text Books, and/or reference material	**Text Books:** 1. Refrigeration and Air-conditioning-- W. F. Stoecker, J. W. Jones 2. Refrigeration and Air-conditioning-- C. P. Arora 3. Power Plant Engineering-- P. K. Nag 4. Power Plant Engineering-- F. T. Morse 5. Steam Turbine Design and Practice-- Kaerton
	Reference Books: 1. Jeffrey M Gordon, Kim Choon Ng, Cool Thermodynamics, Viva Books, 2008. 2. Refrigeration and Air-conditioning-- R. C. Jordon, G. B. Priester 3. Modern Air-conditioning, Heating and Ventilation-- W. H. Carrier, R. E. Cherne

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 653	**Machine Design Sessional - I**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 401, MEC 503		CT+EA					
Course Outcomes	CO1: Acquire basic idea about making the design and production drawing for simple and common mechanical assembly. CO2: To understand the method of implementation of engineering tolerances. CO3: To identify the importance of using the standards and use of catalogues in making the design.						
Topics Covered	Design and Drawing of Machine Elements: Cotter joint, Flexible Coupling, Screw Jack. (36) Problems as assigned by the concerned teacher (6)						
Text Books, and/or reference material	**Text Books:** 1. Design of Machine Elements – V.B. Bhandari 2. Design of Machine Elements – M.F. Spotts 3. Design Data Book – P.S.G. College of Technology, Coimbatore.						

	Reference Books: 1. Mechanical Engineering Design – J.E. Shigley 2. Fundamentals of Mechanical Design – R.M. Phelan

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 654	**Manufacturing Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
WSS51, MEC 402		CT+EA					

Course Outcomes	CO1: Hands on practice on different job manufacturing by milling machine CO2: Understanding power transmission mechanism in lathe, drilling machine, Milling machine etc. CO3: Exposure to grinding machine and job practice CO4: Exposure to NC/CNC machines, part programming, and job practice CO5: Job practice in nonconventional machining, ECM, EDM etc.
Topics Covered	Centre lathe - general features, parts and functions, Mechanism of power transmissions. Lathe operations - straight, taper and eccentric turning, thread cutting, drilling, boring, profile turning, knurling. Horizontal and Vertical milling machine – Spindle drives and feed motion - Milling cutters – indexing head – Simple, compound and differential indexing, Shaping machine – cutting motion and feed motion, slotting machine, Grinding machine – Cutting variables - selection of speeds, feeds and depth of cut - use of cutting fluids - Methods of holding work. Grinding machine – Surface grinding Unconventional machining, NC/CNC machine. **Exercises:** Shaping and slotting Exercises -Flat and bevel surfaces, grooves, Slots, guide ways, key ways etc. Exercises in horizontal and -surface, slot, key way and gear milling- Vertical milling machine. Grinding Exercises. Non – traditional Machining, NC/CNC Machining.
Text Books, and/or reference material	**Text Books:** 1. Manufacturing Processes for Engg. Materials - Kalpakjian 2. Production Technology (vol I & II)—R. K. Jain and S.C. Gupta 3. A Course in Workshop Technology (vol I & II)-- B.S.Raghuwanshi
	Reference Books: 1. Manufacturing Science-- A. Ghosh, A.K.Mallik 2. Principles of Foundry Technology-- P.L.Jain

SEVENTH SEMESTER

<table>
<tr><td colspan="10">Department of Management Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MSC731</td><td>PRINCIPLES OF MANAGEMENT</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1:To make budding engineers aware of various management functions required for any organization
• CO2:To impart knowledge on various tools and techniques applied by the executives of an organization
• CO3:To make potential engineers aware of managerial function so that it would help for their professional career
• CO4:To impart knowledge on organizational activities operational and strategic both in nature
• C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT I: Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization(8)
UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7)
UNIT III: Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8)
UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8)
UNIT V: Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books</u>:
1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House.
2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India
3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education
4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson</td></tr>
</table>

	Prentice hall India 5. Operations Management, 7th edition (Quality control, Forecasting), Buffa&Sarin, Willey Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs **COs**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	2	2	
CO2				2					2	2		
CO3				2					3	2		
CO4							1		3			
CO5				2					2	2	2	

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 710</td><td>Finite Element Method</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Corse Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 301 (Solid Mechanics,) Basic Engineering Mathematics</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To obtain an understanding of the fundamental theory of the FEA method
CO2: To develop the ability to generate the governing FE equations for systems governed by partial differential equations
CO3: To understand the use of the basic finite elements for analysis of bar, truss, beam etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Approximation Methods for solving Differential Equations, weak form of differential equation 8
One-dimensional FE formulation 6
FE formulation of truss and frames 5
Two dimensional FE formulation, Plane stress/ plane strain problem, Axisymmetric problem. 8
FE formulation for bending of beam 5
Free vibration of bar and beam 6
Concept of continuity and convergence criteria. 4</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. Text book of Finite Element Analysis by P. Sesu (PHI) 2. Introduction to Finite Elements in Engineering by T. R. Chandrupatla, A. D. Belegundu (Prentice- Hall) 3. An Introduction to the Finite Element Method by J. N. Reddy (Tata McGraw Hill) **Reference Books:** 1. Finite Element Procedures by K. J. Bathe (Prentice Hall) 2. Finite Element analysis Theory and Programming by C. S. Krishnamoorthy (Tata McGraw Hill) 3. Concepts and applications of finite element analysis by R. D. Cook, D. S. Malkus etc. (Wiley)

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE711	**Computational Fluid Dynamics and Heat Transfer**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC303 (Fluid Mechanics) & MEC304(Thermodynamics)		CT+EA					
Course Outcomes	CO1: To learn to model a physical Fluid Mechanical and Heat Transfer problem (both Laminar & Turbulent Flow) mathematically in terms of PDEs. CO3: To learn discretization of the PDEs using Finite Difference and Finite Volume Methods CO3: To learn R-K4 method to solve ODEs and Techniques to solve PDEs. CO4: To learn to solve simple Heat transfer Problems and Viscous Incompressible Fluid Flow problems using MATLAB coding and checking the same by simulation using ANSYS-Fluent software.						
Topics Covered	**Conservation equations of fluid flow and heat transfer:** Mass, momentum (NS-equation), energy conservation equation and equation of state, Stream function- Vorticity method and Laminar Boundary layer equations for Viscous and Thermal Boundary layer. Classification of PDEs: Elliptical, Parabolic and Hyperbolic PDEs, Initial and Boundary value problems, some examples. Numerical methods: (1) Jacobi Iteration, (2)Point Gauss Siedel iteration (3), Line Gauss Siedel iteration (4) Point Successive over / under relaxation method and (5) TDMA using Thomas Algorithm. 9						

	Turbulence modeling: (1) RANS equations with (a) Mixing length model, (b) The k-ε model and (c) k-ω model. (2) Large eddy Simulation (Concept only) and (3) Direct Numerical Simulation, DNS (Issues and concepts). 5 **Discretization techniques of PDEs:** **Finite Difference Methods**: Central, Forward and Backward Differencing for both uniform and non-uniform grids. Numerical errors and accuracy; Consistency, Convergence and Stability of finite difference scheme. Grid generation, Discretization and solution using Matlab coding of both Steady and Unsteady Diffusion problems and Convetion-Diffusion problems. **Finite volume Method**: Conservativeness, Boundedness and Transportiveness, Central differencing schemes, Upwind differencing schemes, Hybrid differencing schemes and Power law schemes, Quadratic Upstream Interpolation for Convective Kinetics(QUICK). 14 **Numerical methods for Viscous Incompressible Fluid Flow:** Runge-Kutta methods and its application to solve Viscous Boundary layer equations (Blasius equation for flat plate) and Thermal boundary layer equations. Stream function- Vorticity method, MAC algorithm, SIPLE, SIMPLER, SIMPLEC and PISO to solve Viscous incompressible fluid flow. 14
Text Books, and/or reference material	Text Books: 1. Pradip Neogy, S. K. Chakraborty and M. K. Laha: Introduction to Computational Fluid Dynamics; 2. H. K. Versteeg. and W. Malalasekera : An Introduction to Computational Fluid Dynamics: The Finite Volume Method. 3. P.S. Ghoshdastidar: Computational Fluid Dynamics and Heat Transfer. Reference Books: 1. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 2002. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Ane Books-New Delhi, 1980. 2. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology, 2006. 3. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 712	**Design and Optimization of Thermal Systems**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MEC 304, MEC 403, MEC 502	CT+EA

Course Outcomes	CO1: Latest methodologies for the design of thermal system CO2: Use of economics, system simulation and optimization method for thermal system CO3: Will learn exergy analysis and its application for thermal system CO4: Use of thermo-ecological parameters to assess various thermal system CO5: Modeling of energy system
Topics Covered	<u>1. Introduction to Thermal System Design</u> Introduction, Life cycle design Thermal system design aspects Computer aided thermal system design <u>2. Thermodynamics, Modelling, and Design Analysis</u> Basic concepts and definition Control volume aspects Property relations Reacting mixtures and combustion Modelling and design of piping systems <u>3. Thermodynamic Modelling of Polygeneration System</u> Modelling of Power Generation Modelling of Cogeneration Modelling of Polygeneration <u>4. Exergy Analysis</u> Why exergy and energy analysis Balances for mass, energy and entropy Physical exergy, Chemical exergy Exergy for systems and flows Exergy balance Reference environment Applications
	<u>5. Applications with Thermodynamics and Heat and Fluid Flow</u> Heat transfer, Heat exchangers Trade-off between thermal and fluid flow irreversibility Application to power generation and refrigeration <u>6. Economic Analysis</u> Estimation of capital investment Principles of economic evaluation Cost of utility Profitability evaluation <u>7. Thermoeconomic Analysis and Evaluation</u>
Text Books, and/or reference material	Text Books: 1. Bejan A., Tsatsaronis G., Moran M.; Thermal design and optimization. Wiley. 2. Jaluria Y., Design and optimization of thermal system. CRC Press. 3. Szargut J., Exergy method: Technical and ecological applications. WIT Press. 4. Dincer I., Rosen MA., Exergy: Energy, environment and sustainable development. Elsevier.

<table>
<tr><td colspan="9">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 713</td><td>Non-conventional Machining</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 402</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Cutting edge technology for nonconventional/ precision machining.
CO2: Emerging trend of metal removal process</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction 1
ECM: Working Principle; ECM Machine Tool; Process performances; Advantages, limitations and applications; ECG- Working Principles; ECG Machine Tool; Process performances; Advantages, limitations and applications; Electrochemical Debarring (ECDe), Shaped Tube Electrolytic Machining (STEM). 8
AJM, Water Jet Machining and Abrasive Water Jet Machining 8
USM: Working Principles, USM Machine Tool, Mechanics of cutting, Process capabilities, Advantages, limitations and applications. 4
FIB: Working Principles, Machine Tool , Mechanism of material removal and surface modification 4
EDM: Working Principles, EDM Machine Tool – Power Supply, Dielectric System, Electrodes, Servo-system, Pulse generating Circuits and analysis, Process Variables and Process Characteristics; Electrical Discharge Grinding; 4
Wire-cut EDM: Working Principles, EDM Machine Tool, Process Variables and Process Characteristics 4
LBM: Production of LASERs, Working Principles of LBM, Types of LASERs, Process characteristics, Advantages, Limitations and Applications. 3
EBM: Production of Electron Beam, Working Principles of EBM, Focusing and control of electron beam, Process characteristics, Advantages, Limitations and Applications. 3
Chemical Machining, Micro fabrication and Micromachining 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Non-conventional Machining Process: V. K. Jain
2. Modern Machining Processes: Pandey and Shan</td></tr>
<tr><td colspan="7">Reference Books:
1. Manufacturing Science: Ghosh and mallik
2. Non-conventional Machining Process: P. K. Mishra</td></tr>
</table>

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE714	**Advanced Welding Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC402 (Casting, Forming and Welding)		CT+EA					
Course Outcomes	• CO1 : To get the knowledge about newly developed welding process and its parameters • CO2 : To learn various nonconventional welding methods • CO3 : To learn various application fields of various welding processes						
Topics Covered	**Welding :** Definition, requirements, Conditions for ideal weld, Classification of welding processes (1) **Arc Welding :** Arc Initiation, Arc Physics, Arc Maintenance, Power Sources, Power Factor, Duty Cycle, SMAW, GMAW, GTAW, SAW, ESW, EGW, PAW, AHW (10) **Electrodes :** Electrode Classification, Electrode Nomenclature, Electrode composition, Basicity Index, Role of different elements, Coating Factor, Selection of electrodes (3) **Weld design and associated symbols (5)** **Shielding Gases:** Types, roles, features, Selection (1) **Weld Metallurgy**: Zones in a weld, HAZ and its calculation, Weld Decay, Weld Distortion, Residual Stresses – their causes, identification and remedy (3) **Solid State welding Processes** – Forge Welding, Cold Welding, Friction Welding, Friction Stir Welding (6) **Thermo- Chemical Welding Processes** – Thermite welding, etc (3) **Radiant Energy welding Processes** – Electron Beam Welding, Laser Beam Welding, Ultrasonic Welding (5) **Welding at Micro and Nano Scale (3)** **Automation in Welding (2)**						
Text Books, and/or reference material	Text Books: 1) Richard L. Little, Welding and Welding Technology, Tata McGraw Hill, 2004 2) J.F.Lancaster, Metallurgy of welding, Allen & Unwin, London, 1980 Reference Books: 1) V. Tsegelsky, The Electric Welder, Mir Publishers, Moscow, 1968						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 715	**Robotics**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Knowledge on Mechanisms	CT+EA
Course Outcomes	CO1: Students will be able to discuss the history, concepts and key components of robotics technologies. (a, g) CO2: Students will be able to analyse and solve problems spatial transformation, forward and inverse kinematics, dynamics of robot manipulators, jacobian and singularities, joint trajectory for motion planning. (a, e, f, k, g) CO3: Students will be able to describe and compare various robot grippers, sensors, actuators and controllers and their perception. (a, e, k)
Topics Covered	Introduction to Robotics: Definition, Anatomy, Coordinate Systems, Work Envelopes, Basic structure, classification, applications of robots. 4 Robot Arm Kinematics: Frame transformation, Denavit-Hartenberg convention, Forward and Inverse kinematics of serial manipulator. 10 Linear and Angular Velocity of Links and Statics of Serial manipulator: Jacobians, Singularities.6 Introduction to Dynamics of Serial Manipulators: Lagrange-Euler formulation. 5 Trajectory Planning of Manipulator: Joint space scheme, Cartesian space scheme. 5 Robot Sensors: Contact type, non-contact type, internal sensor, External sensor, Range sensor, Proximity sensor, touch sensor, Force and torque sensor, Encoders, etc. 7 Robot Grippers. 3 Robot Controllers 2
Text Books, and/or reference material	**Text Books:** 1. Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence¸ McGraw- Hill, 1987. 2. Craig, J. J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, 1989. 3. Saha, S. K., Introduction to Robotics, TMH Publishing Company Ltd., New Delhi, 2008. 4. Pratihar, D. K., Fundamentals of Robotics, Narosa Publishing House, India, 2017.
	Reference Books: 1. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008. 2. Spong, M. W., Hutchison, S., and Vidyasagar, M., Robot Modeling and Control, Wiley India, New Delhi, 2006.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 716	**Mechanical Equipment Design**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 401 Design of Machine Elements & MEC 503 Machine Design		CT+EA					
Course Outcomes	CO1: Exposure to various types of mechanical elements and their design procedure. CO2: Ability to design different mechanical systems independently. CO3: Understand the working of various types of drive systems. CO4: Dealing with the case studies help develop self-confidence.						
Topics Covered	Chain Drive 4 Rope Drive 4 Spiral Bevel Gear Drive 4 CVT Mechanism 4 Design of Pulley and Idlers 5 Design of Worm Gears 4 Cam Mechanisms 4 Disc Brakes 4 Selection of Single-Phase Induction Motors 3 Case Studies 6						
Text Books, and/or reference material	**Text Books:** 1. Black and Adams, Machine Design, McGraw Hill Book Company Private Ltd., USA, 1973. 2. Phelan R.M., Fundamentals of Mechanical Design, TMH, 2015.						
	Reference Books: 1. Burr, Arthur H., and Cheatham, John B., Mechanical Analysis and Design, Prentice Hall, USA,1995 2. Norton, R.L. , Machine Design: An Integrated Approach						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 717	**Control Systems**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 302, MEC 502		CT+EA					

Course Outcomes	CO1: Will get exposure to the block diagram based formulations, behavior of linear time continuous control systems. CO2: Ability to analyze the system performance and relative stability information. CO3: Understand the relevance of characteristic roots in the behavior of various dynamic systems. CO4: Ability to design simple controllers for analog systems. CO5: To study and analyze state space methods, controllability and observability of control systems.
Topics Covered	Introduction to Control, Systems and Elements, Transducers, Feedbacks, Classification of systems3 Mathematical modelling, Block Diagram and Transfer Functions 4 Analysis of Response of simple feedback control systems 5 Structure of Control systems and Control Laws 4 Root locus plot and analysis 5 Stability analysis by frequency response methods – Nyquist and Bode diagrams 5 State-space representations 5 PID controllers – Analysis and design 5 Digital Control Methods.2 Design of Control Systems in Matlab Simulink Environment.2 Examples of Control Systems, Laboratory Exercises.2
Text Books, and/or reference material	**Text Books:** 1. Kuo, B. C., Automatic Control System, 3rd Edition, Prentice Hall Inc., New Jarsey, 1975. 2. Nise, N. N., Control Systems Engineering, 6th Edition, John Wiley & Sons, Inc., USA, 2011.
	Reference Books: 1. Raven, F. H., Automatic Control Engineering, McGraw Hill Book Company Private Ltd., USA, 1961.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 718	**Fundamentals of Combustion**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 304, MEC 403, MEC 502		CT+EA					
Course Outcomes	CO1: To understand the physical process involved in combustion CO2: To be able to model a process involving combustion. CO3: To acquire an in-depth idea about laminar flames. CO4: To understand partially premixed flames. CO5: To learn the intricacies of turbulent flames.						

Topics Covered	Review of thermodynamics, Chemical kinetics, Mass transfer definitions: Fick's law Equations of conservation of species mass, momentum, and energy; multi-component diffusion equation Schvab-Zel'dovich formulation, Rankine-Hugoniot relations. Laminar premixed flames: Flame speed, flammability limits, flame stabilization, ignition and quenching. Laminar diffusion flames: Burke-Schumann problem and droplet burning. Partially premixed flames
Text Books, and/or reference material	**Text Books:** 1. Principles of Combustion – K. K. Kuo 2. An introduction to combustion – S. R. Turns
	Reference Books: Combustion physics – C. K. Law

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 719	**Modeling and Simulation of Dynamic Systems**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics, Strength of Material, Dynamics of Machine.		CT+EA					
Course Outcomes	CO1 By the end of the course students are able to know the fundamental of modeling and simulation and its usefulness. CO2 Overview of various modeling software and its usefulness in development of mathematical model. CO3 Modeling concept for electro-mechanical, mechatronics systems and feedback control. CO4 Interpretation of simulation results and diagnosis of systems.						
Topics Covered	Introduction to system modelling 6 Introduction to modeling with examples, introduction to simulation, MATLAB and Simulink, bond graph and Adams multi-body simulation tools. Modeling of dynamic systems 6 Introduction to dynamic systems with examples, bond graph modeling, causality, generation of system equations, Methods of drawing bond graph models of electrical and mechanical systems. Modeling of systems (fundamental model) 8						

	Fundamental models of mechanical, electrical, hydraulic, pneumatic and thermal systems, hydraulic and thermal system modeling, examples of fundamental systems such as two-tank system, thermal damping, compressor-reservoir system, etc. Modeling of systems (as a combination of subsystems) 10 Linear and nonlinear systems, modeling of systems: a combination of translational and rotational systems, hydro-mechanical systems and electro-mechanical systems, modeling of mechatronic systems and feedback control of mechanical systems. Simulation and its applications 10 Simulation using Simulink, bond graph and Adams, simulation of simple and compound pendulum, simulation of planar mechanisms, validation of simulation results with examples.
Text Books, and/or reference material	**Text Books:** 1. Bond graph in modeling simulation and fault identification, Amalendu Mukherjee, Arun Kumar Samantaray, and Ranjit Karmakar, CRC Press. 2. MATLAB for mechanical engineers, Rao V. Dukkipati, New age International.
	Reference Books: 1. Measurements, Modelling and Simulation of Dynamic Systems, Edward Layer, Krzystof Tomczyk, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG. 2. Modelling and simulation Exploring Dynamic System Behavior, Louis G. Birta, Gilbert Arbez, Springer London Ltd

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 720	**Non-Linear Vibration**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 301, MEC 302, MEC 504		CT+EA					
Course Outcomes	CO1: Understanding the various characteristics of nonlinear dynamic system. CO2: Development of solution procedures employing approximate methods. CO3: Develop the concept of stability and different methods for stability and bifurcation analysis. CO4: Analysis of nonlinear system employing numerical techniques and comparing the results with approximate methods.						

Topics Covered	**Introduction:** linear and nonlinear systems, conservative and non-conservativesystems; potential well, Phase planes, types of forces and responses, fixedpoints, periodic, quasi-periodic and chaotic responses; Local and globalstability; commonly observed nonlinear phenomena: multiple response, bifurcations, jump phenomena. 9 **Analytical solution methods:** Harmonic balance, perturbation techniques (Linstedt-Poincare', method of Multiple Scales, Averaging method) 6 **Stability and bifurcation analysis:** static and dynamic bifurcations of fixed pointand periodic response, different routes to chaotic response. 6 **Numerical techniques:** Time response, phase portrait, FFT, Poincare' maps, point attractors, limit cycles and their numerical computation, strange attractor sand chaos; Lyapunov exponents and their determination, basin of attraction: point to point mapping and cell to cell mapping, fractal dimension. 9 **Applications:** Single degree of freedom systems: Free vibration-Duffing'soscillator; primary-, secondary-and multiple- resonances; Forced oscillations: Van der Pol's oscillator; parametric excitation: Mathieu's and Hill's equations, Floquet theory; effects of damping and nonlinearity. Multi degree of freedom and continuous systems. 10
Text Books, and/or reference material	**Text Books:** 1. Nayfeh, A. H., and Mook, D. T., Nonlinear Oscillations, Wiley-Interscience,1979. 2. Hayashi, C. Nonlinear Oscillations in Physical Systems, McGraw-Hill,1964.
	Reference Books: 1. Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers, D. Jordon and P. Smith, Oxford 2. Evan-Ivanowski, R. M., Resonance Oscillations in Mechanical Systems,Elsevier. 3. Nayfeh, A. H., and Balachandran, B., Applied Nonlinear Dynamics, Wiley. 4. Seydel, R., From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, Elsevier.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 721	**Convective Heat and Mass Transfer**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 303, MEC 304, MEC 403		CT+EA					

Course Outcomes	CO1: To acquire an idea about convective transport mechanism CO2: To learn the basics of convective heat and mass transfer CO3: To learn about internal and external convection CO4: To learn about forced and natural convections CO5: To learn about heat transfer in phase change
Topics Covered	Fundamental principles: Basic laws of fluid mechanics and thermodynamics, scale analysis 4 Laminar Boundary Layer: Concept of velocity and temperature boundary layers, integral solutions, similarity solutions, different wall heating conditions. 4 Laminar Duct Flow: Heat transfer to developed and developing duct flows. 4 External natural convection. 4 Internal natural convection. 4 Turbulent boundary layer flow and turbulent duct flow 5 Free turbulent flows: shear layer, jets and plumes. 4 Convection with change of phase. 6 Mass transfer. 7
Text Books, and/or reference material	**Text Books:** 1. Convection Heat Transfer – A. Bejan 2. Convective Heat Transfer -- L.C. Burmeister 3. Convective Heat and Mass Transfer – Kays and Crawford
	Reference Books: 1. Principles of Convective Heat Transfer – M. Kaviany 2. Convective Heat and Mass Transfer – S. M. Ghiaasiaan 3. Heat Convection – L. M. Jiji

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 722	**Additive Manufacturing**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Manufacturing Technology, Machine Tool		CT+EA					
Course Outcomes	CO1: Able to understand the principles of different additive manufacturing processes CO2: Able to learn software's for additive manufacturing CO3: Able to expose materials for Additive Manufacturing and it's selection CO4: Able to know areas of usage, possibilities and limitations of the additive manufacturing technologies						

Topics Covered	Introduction to Additive Manufacturing (AM), Overview, History, Need, Classification, Additive Manufacturing Technology in product development2 CAD & Reverse Engineering, CAD model preparation – Part Orientation and support generation, Model Slicing, Tool path Generation, Software's for Additive Manufacturing Technology , Model Reconstruction – Data Processing for Additive Manufacturing Technology, Reverse engineering 6 Materials for Additive Manufacturing Technology 4 Different AM processes and relevant process physics, AM process chain 8 Sheet Lamination Processes1 Photo-polymerization Processes2 Extrusion-Based Systems1 Powder Bed Fusion Processes3 Binder jetting 1 Material jetting 2 Directed Energy Deposition Processes3 Micro & Nano additive manufacturing processes 4 Design for Additive Manufacturing3 Applications of Additive Manufacturing 2
Text Books, and/or reference material	**Text Books:** 1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer. 2. C.K. Chua, K.F. Leong and C.S. Lim, 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific.
	Reference Books: 1. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 723	**Energy Conversion Systems**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC601 (Power Plant Engineering)		CT+EA					
Course Outcomes	CO1: Acquire an idea about different energy conversion technologies CO2: To learn the energy efficient, economically viable, and environmental friendly power generation technologies CO3: To learn about different conventional and non-conventional power generation systems. CO4: Introduced to different direct energy conversion systems						

Topics Covered	Global and Indian Energy Scenario 3 Advanced Coal Technologies 6 Advanced Power generation Cycles-Supercritical Power plant, Cogeneration, Combined cycle power plants 7 Fluidized bed combustion 5 Gasification, Integrated Gasification Combined Cycle (IGCC) 6 Direct Energy Conversion: Fuel Cells: Proton Exchange Membrane (PEM) Fuel cells, Solid Oxide Fuel Cells (SOFC), Magneto-Hydro-Dynamic (MHD) Systems 7 Biomass based energy conversion 3 Nuclear Power generation 5
Text Books, and/or reference material	**Text Books:** 1. Principles of Energy Conversion-Archie W. Culp 2. Power Plant Engineering-P.K. Nag **Reference Books:** 1. Fluidized Bed Technology-J.R. Howard 2. PEM Fuel Cells: Theory and Practice- Frano Barbir

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 724	**Hydraulic Machines**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC303		CT+EA					
Course Outcomes	CO1: To acquire an in depth knowledge of hydraulic machines used in the Industry CO2: To learn the basic design procedure for different hydraulic machines						
Topics Covered	Principles of Similarity, Specific Speed and Unit Quantities (4) General classification of hydraulic machines - basic principles, torque, power and efficiency. (2) A Brief introduction of 2 D Cascade Theory for Rotodynamic Machines (4) Hydraulic Turbines: (12) Classification and types of Turbines. Impulse Turbine:- Pelton Wheel;. Reaction Turbine:- Francis, Propeller and Kaplan turbines; Effective head, Available head and efficiency; Force, Torque, Power, Efficiency and Operation of Turbines; Principles of similarity; Specific speed; Cavitation; Setting of turbines; Draft tubes; Penstocks; Surge tanks; Performance characteristics curves; Selection of types and speeds of turbines; Governing of turbines.						

	Pumps: (12) Pumps: Classification ; Rotodynamic pumps:- Centrifugal and Axial flow pumps ; Torque, Power, Efficiency and Operation; Performance Characteristics; Principles of Similarity and Specific speed; Energy losses in pumps; Cavitation; Priming; Power requirements; Homologous operation; Series and Parallel operation; Multistage pumps; Selection and installation of pumps of various duties; Testing of pumps. Cavitation and setting height of turbo machines Reciprocating pumps:- Types; Working principle; Instantaneous discharge and average discharge; Slip; Negative slip, Coefficient of discharge and volumetric efficiency; Work done and overall efficiency; Indicator diagram:- effect of inertia and friction on suction and delivery pipes; Separation head; Effect of bend on delivery pipe; Air vessels; Power saved by air vessels in overcoming pipe friction; Discharge in and out of air vessel. Hydraulic coupling; Torque converter (2)
Text Books, and/or reference material	**Text Books:** 1. Mechanics of Fluids: Massey, B. S. 2. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, et al. 3. Hydraulic Machinery - Jagdish Lal

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE725	Introduction to Aerospace Engineering	PEL	3	0	0	3	3
Pre-requisites							
MAC301, PHC01		CT+EA					
Course Outcomes	CO1: Understand basics of aerospace engineering CO2: Apply the concept of static stability to flight vehicles CO3: Describe the concepts of stress, strain, Young's modulus, Poisson's ratio, yield strength CO4: Demonstrate understanding of basic knowledge of propulsive devices and basic knowledge of dynamics relevant to orbital mechanics						
Topics Covered	**Unit 1:** Aero/Hydrodynamics Introduction and Historical Development of flights, standard atmosphere, various altitude definitions, Define pressure, temperature and density of altitude. Viscosity and its implications, shear stress, the Lagrangian and Eulerian viewpoints of a flow field, concept of a streamline, Conservation Equations, Bernoulli's equation Introduction to compressible flow (CO1) **Unit 2:** Wing Geometry Common aircraft terminology and geometry, Identify basic aircraft types and discuss their features, Wing Loading and Thrust Loading, Basic Design - Lift and Drag, Calculation of the lift and drag coefficients using NACA data.(CO1) **Unit 3:** Performance and Propulsion Basic principles of Propulsion, Historical background, Classification of propulsive devices, Applications of aircraft and rocket engines, Elements of combustion: thermochemistry, Adiabatic temperature, Chemical Equilibrium, viscous and						

	pressure drag components on a body, flow separation, types of aerodynamic drag, lift and drag calculations on aircraft. (CO4) **Unit 4:** Aircraft Stability Six degrees of freedom of aircraft motions, Stable, unstable and neutral stability, Difference between static and dynamic stability, Static longitudinal stability for aircraft, Coupling in lateral and directional stability.(CO2) **Unit 5:**Aircraft Structure Primary load carrying members, perform a spar cap sizing example and understand the basic V-n diagram. (CO3) **Unit 6:** Space Applications History of space research, Orbital motion including typical spacecraft trajectories and basic orbital maneuvers, Six orbital elements, Kelper's laws of orbits, Newton's law of gravitation.(CO4)
Text Books, and/or referenc e material	1. John D. Anderson, Introduction to Flight, 8th Edition, McGraw-Hill Education, New York, 2015. 2. Manuel SolerArnedo, Fundamentals of Aerospace Engineering, Second Edition, Creative Commons Attributes- Share Alike 3.0,2017.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 751	**Hydraulic Machine Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fluid Mechanics		CT+EA					
Course Outcomes	CO1: To understand the principle of linear momentum.. CO2: To understand the performance characteristics of various pumps. CO3: To understand the performance characteristics of various turbines.						
Topics Covered	Performance of Centrifugal Pump. Performance Test of Reciprocating pump. Performance Test of Pelton Wheel. Performance Test of Kaplan Turbine. Performance Test of Francis Turbine.						
Text Books, and/or reference material	**Text Books:** *1.* Mechanics of Fluids: Massey, B. S. 2. Fluid Mechanics – J. F. Douglas, J. M. Gasiorek, J. A. Swaffied, L. B. Jack 3. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, *et al*. 4. Hydraulic Machinery - Jagdish Lal **Reference Books:** 1. Fluid Mechanics—F. M. White						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 752	**Machine Design Sessional - II**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 503		CT+EA					
Course Outcomes	CO1: Acquire basic idea about making the design and production drawing for relatively complicated mechanical systems for example gear boxes. CO2: To understand the method of implementation of engineering tolerances. CO3: To learn about economic design procedures.						
Topics Covered	Design and Drawing of Gear Box (36) Problems as assigned by the concerned teacher (6)						
Text Books, and/or reference material	**Text Books:** 1. Design of Machine Elements – V.B. Bhandari 2. Design of Machine Elements – M.F. Spotts 3. Machine Design: P. H. Black and O. E. Adams 4. Design Data Book – P.S.G. College of Technology, Coimbatore.						
	Reference Books: 1. Mechanical Engineering Design – J.E. Shigley 2. Fundamentals of Mechanical Design – R.M. Phelan 3. Machine Design: An Integrated Approach – R.L. Norton						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEO 741	**Non-conventional Energy Systems**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: Identify and explain the use of non-conventional energy systems. CO2: Develop an understanding that solutions to energy-related problems are complex involving sociological, economic, political and technological considerations, decisions and development. CO3: Gain insight into the issues surrounding non-conventional energy sources development and use. CO4: Become knowledgeable about applications of non-conventional energy systems as they apply to commercial, residential and industrial markets.						

Topics Covered	Traditional energy systems, Sources, Features and characteristics, applications2 Component of solar energy systems, Collector types and performances, Radiation and meteorological data processing, Long term conversion factors, System conversion and system design procedures, Solar power generation, Solar heating and cooling, Solar passive systems: Solar still, Pond, Greenhouse, Dryer, Trombe wall, Overhangs and Wing walls. 13 Wind energy conversion systems, Estimate of wind energy potential, Aerodynamic and mechanical aspects of wind machine design. 4 Principles and applications of wave energy, Shoreline systems, Near shore systems, Off shore systems 3 Tidal energy, Biomass energy, Operating principle, Wood gassifier, Pyrolysis, Applications, 4 Geothermal energy and OTEC. 4 Fuel cell: Types and technology status. 3 Hydel Power Plant: Introduction to hydro-electric power generation, Types of Hydel turbines, Layout and selection of turbines and installation, Geographic limitations, Turbine performance, Comparative analysis between thermal and hydel plants. 9
Text Books, and/or reference material	**Suggested Text Books:** 1) Solar Energy Fundamentals and Applications-- Garg and Prakash 2) Solar Energy-- S. P. Sukhatme **Suggested reference books:** 1) Fundamentals of Renewable Energy Systems-- D. Mukherjee and S. Chakrabarti 2) Non-conventional Energy Sources-- D. S. Chauhan and S. K. Srivastava

EIGHTH SEMESTER

<table>
<tr><td colspan="9">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 810</td><td>Solar Energy</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 304, MEC403, MEC 502, MEC 601</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Identify and explain the use of active, passive solar thermal systems.
CO2: Develop an understanding that solutions to energy-related problems are complex involving sociological, economic, political and technological considerations, decisions and development.
CO3: Gain insight into the issues surrounding solar energy development and use.
CO4: Become knowledgeable about applications as they apply to commercial, residential and industrial markets.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Solar Radiation and Measurements: 7
Solar energy option - an overview, Fundamentals of solar radiation, Basic Earth sun- angles, Solar time and equation of time, measurements, Empirical equations for predicting the availability of solar radiation, Computation of radiation on a surface
Liquid Flat Plate Collectors: 8
Liquid flat plate collector design, Efficiency of flat plate collectors and performance analysis,
Flat plate solar air heaters, Other types of solar air heaters, some novel designs, Performance analysis and testing procedures.
Solar Concentric Collectors: 6
Cylindrical parabolic collectors, Performance analysis of cylindrical parabolic collectors, Compound parabolic concentrating collectors, Performance analysis of compound parabolic concentrating collectors, Paraboloid dish collectors.
Solar Thermal Energy Storage system: 5
Need of thermal energy storage, Size and duration of storage, Sensible heat storage, Latent heat storage, PCM, Thermo-chemical energy storage.
Solar Thermal Applications: 8
Solar space heating, active systems, passive system - Trombe wall, Solar refrigeration and air conditioning, Solar cookers, Solar desalination, Solar dryers, Solar ponds and its thermal performance, Solar energy for industrial process heat
Solar Thermo-Mechanical Power Generation: 8
Principles of solar engines, limitation of solar mechanical power conversion, Types of solar power plants, Solar chimney, Parabolic through power plants, Central receiver power plants. Solar furnaces.</td></tr>
</table>

Text Books, and/or reference material	Suggested Text Books: 1. Sukhatme S. P., “Solar Energy: Principles of Thermal Collection and Storage,” 3rd Ed., Tata McGraw-Hill Publishing Company Ltd. 2. H. P. Garg and J. Prakash, Solar Energy: fundamentals and applications, 1st Ed., Tata McGraw-Hill Publishing Company Ltd. Suggested Reference Books: 1. Solar energy Process – Duffie and Beckman, John Wiley

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 811	**Mechatronics**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MEC 301, MEC 504	CT+EA

Course Outcomes	CO1: Students will be able to identify the importance of amalgamation between the electronics and electro-mechanical systems. CO2: Students will be able to formulate and evaluate behavior of linear time continuous control systems. CO3: Students will be able to formulate the procedure for converting analog signals to digital form and vice-versa. CO4: Students will be able to describe signals and its processing by modern electronic methods. CO5: Students will be able to identify and critically evaluate current developments and emerging trends within the field of mechatronic systems.
Topics Covered	Mechatronic Systems: Introduction, Application of Mechatronics. 2 Sensors and Transducers - Brief review, Simple electronic elements & Operational Amplifiers.4 Actuators: Pneumatic, Hydraulic, Electrical & Mechanical actuation system, Micro-actuators.3 Modelling and Simulation of Physical System: System models, Dynamic responses of the system, System transfer functions.4 Digital logic: Number systems, Boolean algebra, Logic gates - Application gate, Design of logic of digital logic gates.5 Microprocessors and Micro-Controllers: Introduction, Microprocessor Architecture, Instruction codes, General requirements for implementation issues, Examples. 6 Programmable Logic Controllers: Basic structure, I/O processing, Programming, Timer, Inter relays and Counters.6 Signal conditioning & Digital communication system: Basics of signal conditioning, Filtering, Data acquisition and Digital signal processing, Digital communication and Communication interface. 6 Mechatronic Systems, Case Studies.6

Text Books, and/or reference material	**Text Books:** 1. Alciatore, D. G. and Histand, M. B., Introduction to Mechatronics and Measurement Systems, McGraw Hill Publications, 4th Edition, 2012. 2. Bolton, W., Mechatronics, Pearson Education India, 2008. 3. Gaonkar, R.S., Microprocessor Architecture, Programming and Applications with 8085, Penram Publishers India, 6th Edition, 2013.
	Reference Books: 1. Malvino, A. P., and Bates, D. J., Electronic Principles, TMH Publishing Company Ltd., New Delhi, 8th Edition, 2016. 2. Nise, N. N., Control Systems Engineering, 6th Edition, John Wiley & Sons, Inc., USA, 2011.

Department of Mechanical Engineering

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 812	**Micro and Nano Manufacturing**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MEC402 (Casting, Forming and Welding), MEC501 (Machining and Machine Tools)	CT+EA

Course Outcomes	CO1 : To understand the need for micro and nano scale fabrication CO2 : To get acquainted with different micro and nano scale fabrication techniques and their characterization CO3 : To be able to select a suitable micro or nano scale fabrication process based upon the requirement CO4 : To compare and understand the differences between macro and nano scale fabrication processes
Topics Covered	Need for Micro and Nano Scale Manufacturing Processes : Examples of micro and nano scale parts being used in various applications, How the performances of micro/nano scale components are better AFM, STM, SEM, TEM, XRD, 2 **Photo Lithography** : Historical perspective, Overview, Electromagnetic Spectrum Clean Room – Classes, Features Photoresist: Positive and Negative Photo resists; Glass Transition Temperature, Photoresist deposition: Spin coating, Spray coating, Electro-deposition; Baking, Masks, Exposure: Contact Printing, Projection Printing, Proximity Printing, Development, Critical Dimension, Overall Resolution, Line Width Metrology, Resist Profiles, Photolithography Resolution Enhancement Technology : through Improved Resist Performance, through Improved Mask Technology, through Improved Exposure Technology Reducing the minimum feature dimension in photolithography Examples 10 **Dry Etching** Definitions, Plasma, Physics of plasma, Sputtering or Ion Etching, Ion Beam Milling, Plasma Etching, Deep Reactive Ion Etching (DRIE), ICP, Examples 3

	Wet Etching Chemical Milling, Photochemical Milling, Wet Isotropic and Anisotropic Etching, Etch Stop Techniques, 3 Moore's Law , Need for pushing the feature sizes to lower levels, **Next Generation Lithographic Techniques** : EUV , XRL, LIGA, EBL : EBL Resists, electron emission, Ion Beam Lithography, Nano Imprint Lithography, Lithographic techniques still in research and developmental state Examples 12 **Physical VaporDeposition:** Thermal evaporation, Sputtering– DC and RF Sputtering, Pulsed Laser Deposition – Laser sputtering, Aerosol Deposition Examples 4 **Chemical Vapor Deposition**: Overview, description, PVD vs CVD, APCVD, LPCVD, PECVD, ALD, Examples 4 **Micro and Nano Scale Joining Techniques** 2
Text Books, and/or reference material	**Text Books:** 1. Fundamental of Microfabrication and Nanotechnology Volume 2, by Prof Marc J Madou, CRC Press, Taylor and Francis Group 2. Micro and Nanomanufacturing, Mark J Jackson, Springerlink 3. Micro and Nanomanufacturing Volume 2, Mark J Jackson, Springerlink
	Reference Books: Micro/Nano Manufacturing, Hans Nørgaard Hansen and Guido Tosello, MDPI Publishing (for application examples)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 813	**Microfluidics**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MEC303 Fluid Mechanics MEC304 Engineering Thermodynamics MEC403Heat and Mass Transfer PHC01 Engineering Physics CYC01 Engineering Chemistry, BTC01 Life Science	CT+EA

Course Outcomes	CO1: To learn micro channel flows with heat transfer. CO2: To learn Surface Tension Driven Flows with real life applications. CO3: To learn Electro-hydro-dynamics fundamentals CO4: To learn Molecular Dynamics Simulations
Topics Covered	Introduction to Microfluidics: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws, Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations1 Microfluidics- Some Application Examples: Drug delivery, Diagnostics, Bio-sensing 1 Equations of Conservation 1

	Navier Stokes Equation 2 Energy Equation 2 Pressure –driven Micro flows: Exact solutions, Couette flow, Poiseuille flow 5 Some Examples of Unsteady Flows: Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel. 3 Stokes Drag on a Sphere: Stokes drag on a sphere, Time-dependent flows, Two-phase flows 2 Lubrication Theory 2 Boundary Condition in Fluid Mechanics - Slip or No-slip: Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects 2 Surface Tension Driven Flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect 6 Thin Film Dynamics 4 Introduction to Micro-fabrication: Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography-mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer micro fabrication, PMMA/COC/PDMS substrates, micro molding, hot embossing, fluidic interconnections. Electrokinetics: Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electro-osmotic flow, Ideal EOF with back pressure, Cascade electro-osmotic micro pump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric 4 Dispersion, Introduction to Nano fluidics, Introduction to Molecular Dynamics Simulations, Bio microfluidics, Nano fluidic Energy Conversion4
Text Books, and/or reference material	**Text Books:** 1) Microfluidics -Stéphane Colin 2) Micro- and Nanoscale Fluid Mechanics, Transport in Microfluidic Devices-Brian Kirby, Cambridge University Press . **Reference Books:** 1) Theoretical Microfluidics-Henrik Bruus , Oxford University Press. 2) Fundamentals and Applications of Microfluidics: Nam- Trung Nguyen and Steven T. Wereley

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 814	**Machine Tool Engineering and Automation**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ME402		CT+EA					
Course Outcomes	CO1: In depth study of mechanical machine tools construction and design. CO2: Introduction to machine tools automation.						
Topics Covered	General principles of Machine Tool design, Machine Tool drives and mechanisms. 2 Design of speed and feed gear box, Optimum design principles for using double bound gears. 12 Design of Machine Tool structures: beds, slides and guides, selection of bearing for machine tools. 3 Hydrostatic and Hydrodynamic lubrication in Machine Tool slide ways and Guides, Stick-slip motion in Machine Tool slide ways. 3 Machine tool rigidity, system compliance and process capability of machine tools. 4 Machine tool inspection, testing and maintenance. 2 Overview on Automation: Definition, application, advantages and disadvantages. Types of automation: fixed automation (automatic machines, transfer devices and semi-automatics), Programmable automation (NC, CNC and machining centres, DNC, adaptive control machines, Industrial robots, CAD/CAM, CIM) and flexible automation (FMS). 5 CNC Hardware: Constructional features, operational characteristics of CNC machine tools, Machine tool drives, sensing devices, open and close loop control 3 CNC machining, part programming, NC tool path generation. 8						
Text Books, and/or reference material	Text Books: 1. Principles of Machine Tools – Sen and Bhattacharya 2. Computer Controlled of Manufacturing Systems – Y. Koren						
	Reference Books: 1. Machine Tool Engineering – N. K. Mehta 2. Numerical Control and Computer Aided Manufacturing – Kundra, Rao and Tiwari						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 815</td><td>Theory of Plates</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Engineering Mechanics, Strength of Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1:Concept of various plate theory
CO2:Derivation of governing equation using virtual displacement theory
CO3: Analysis of plates</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Stress strain relations, strain displacement relation, equations of equilibrium, virtual work principle, Classical plate theory, FSDT, HSDT. 8
Pure bending and cylindrical bending of isotropic rectangular plates, Navier and Levy solutions of rectangular plates. 8
Bending of circular plates. 6
Bending analysis of laminated composites plates. 8
Approximate solution methods for plate problems. 6
Dynamics of Plates. 6</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Theory of plates By K. Chandrashekhara (Universities Press)
2. Theory and analysis of elastic plates and shells By J. N. Reddy(CRC Press)
3. Theory of plates and shells By S. P. Timoshenko and S. W. Krieger(Tata Mcgraw-Hill)</td></tr>
<tr><td colspan="7">Reference Books:
1. Theory and analysis of plates classical and numerical methods By R. Szilard (Prentice Hall)</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 816</td><td>Advanced Mechanical Vibration</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Fundamentals of Vibrations</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understanding the fundamental material for a modern treatment of vibrations.
CO2: Application of Lagrange equations for lumped and continuous systems
CO3: Understanding fundamentals of beam theory; extensional, torsional, and flexural vibrations of beams.
CO4: Understanding Self-excited vibration, nonlinear vibration etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Review of relevant mathematics: linear algebra 3
Generalized co-ordinates, Lagrange's equations 3
Single-DOF and multi-DOF vibration 7
Vibration Absorber 2
Torsional vibration 4
Periodic excitation and Fourier series, impulse and step response 5
Vibration in continuous systems4
Self-excited vibration, Criterion of stability; Effect of friction 5
Introduction to nonlinear vibration 7</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Mechanical Vibrations, S. S. Rao, Pearson Education Inc. (4th Ed.), 2007.
2. Fundamental of Vibrations Leonard Meirovitch, Mc-Graw Hill Inc., 2001
3. Vibration and Control, D. J. Inman, John Willey & Sons Inc, 2002</td></tr>
<tr><td colspan="7">Reference Books:
1. Mechanical Vibrations, S. Tamadonni & Graham S. Kelly, Schaum's Out line Series, Mc-Graw Hill Inc, 1998.
2. Vibration Condition Monitoring of Machines, J. S. Rao, Tata Mc-Graw Hill, 2006.</td></tr>
</table>

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES, PROGRAM SPECIFIC OUTCOMES

Couse Code and Course Name: MEC301, Solid Mechanics

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC301.1	Understand the analysis of stress, strains, elasticity properties of materials, strain energy principles	3	3	3	1	1	1	1	-	-	1	-	1	2	1
MEC301.2	Demonstrate the members subjected to shear force, bending moments, flexure loads, torsional loads	3	3	3	1	1	1	1	1	-	1	-	1	2	1
MEC301.3	Calculate deflection of beams	3	3	3	1	1	1	1	1	-	1	-	1	2	1
MEC301.4	Estimate the members subjected to compressive loads.	3	3	3	1	1	1	1	1	-	1	-	1	2	1
Average		**3**	**3**	**3**	**1**	**1**	**1**	**1**	**0.8**	**-**	**1**	**-**	**1**	**2**	**1**

Couse Code and Course Name: MEC302, Theory of Machines & Mechanisms

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC302.1	Knowledge of dynamics of elementary mechanisms and machines	3	2	-	1	3	-	-	-	1	-	-	2	3	1
MEC302.2	Knowledge of the fundamental of machine design	3	3	-	1	2	-	-	-	1	-	-	1	3	1
Average		**3**	**3**	**-**	**1**	**2.5**	**-**	**-**	**-**	**1**	**-**	**-**	**1.5**	**3**	**1**

Course Code and Course Name: MEC303, Fluid Mechanics

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC303.1	To understand the fundamental concepts of fluid mechanics	3	2	2	-	-	2	-	1	-	-	2	-	2	-
MEC303.2	To formulate the fundamental equations in mathematical form to solve the fluid mechanics problems	3	2	2	-	-	-	-	1	-	-	-	2	2	-
MEC303.3	To apply the conservation equations to analyse both viscous and inviscid flow	3	2	2	-	-	2	-	1	-	-	-	2	2	-
Average		**3**	**2**	**2**	**-**	**-**	**2**	**-**	**1**	**-**	**-**	**2**	**2**	**2**	**-**

Couse Code and Course Name: MEC304, Engineering Thermodynamics

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC304.1	Enumerate the laws of thermodynamics and systems.	3	3	-	-	-	-	-	-	-	-	-	-		-
MEC304.2	Express the proficiency in handling engineering problems to arrive at substantiated conclusions using laws of thermodynamics.	3	3	2	1	-	-	-	-	-	-	-	-	2	-
MEC304.3	Compute solutions for complex thermodynamic problems.	3	3	3	3	1	-	-	-	-	-	-	-	3	3
MEC304.4	Apply the laws of thermodynamics in different Engineering problems such as heat engines, refrigeration, power cycles, compressors etc.	3	3	3	3	-	-	-	-	-	-	-	3	2	1
MEC304.5	Evaluate the performances of Engineering applications based on thermodynamic laws.	3	3	3	3	-	-	1	-	-	-	1	3	2	2
MEC304.6	Design the Engineering applications based on Thermodynamics.	3	3	3	3	1	-	1	-	-	-	1	3	3	3
Average		**3**	**3**	**2.3**	**2.2**	**0.3**	**-**	**0.3**	**-**	**-**	**-**	**0.3**	**1.5**	**2**	**1.5**

Couse Code and Course Name: MAC-331, Mathematics-III

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MAC331.1	CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.	3	3	3	2	2	1	2	-	-	-	-	2	3	2
MAC331.2	CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems	3	3	2	2	2	1	2	-	-	-	1	2	3	3
MAC331.3	CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.	3	3	2	2	3	-	1	-	-	1	-	2	2	2
MAC331.4	CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.	3	2	2	3	2	1	1	-	1	-	-	2	3	2

Average		**3**	**2.8**	**2.3**	**2.3**	**2.3**	**1**	**1.5**	**-**	**1**	**1**	**1**	**2**	**2.8**	**2.3**
Couse Code and Course Name: PHC333 Physics of Engineering Materials															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
PHC333.1	To understand fundamental theory of metal	3	1	2	3	1	1	2	1	-	1	1	2	-	-
PHC333.2	To comprehend theory and device applications of semiconductor materials	3	3	2	3	-	1	2	1	-	-	-	1	-	-
PHC333.3	To be familiar with fundamental of laser and its applications	3	3	2	3	-	1	2	1	1	1	1	2	2	1
PHC333.4	To know about the super conductivity, dielectric and mechanical properties of material	3	2	2	3	1	1	2	2	1	1	1	1	2	1
Average		**3**	**2**	**2**	**3**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**0.5**
Couse Code and Course Name: PHS383 Physics of Engineering Materials Laboratory															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
PHS383.1	To realize and apply different techniques for measuring characteristics of p-n junction and application of Zener diode as voltage regulator	3	2	2	3	2	2	3	2	2	1	3	2	1	-
PHS383.2	To determine the properties (carrier concentration and type) of semiconductor by Hall-effect experiments	3	2	2	2	-	1	2	2	2	1	3	2	1	-
PHS383.3	To apply the knowledge to determine the properties (bandgap and resistivity) of semiconductor materials by four-probe method at different temperatures.	3	1	1	2	-	1	2	2	2	1	3	2	1	1
PHS383.4	To determine the characteristics of solar cell	3	1	3	3	-	3	3	2	2	1	3	2	-	1
Average		**3**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**2**	**0.8**	**0.8**
MEC401 :: Design of Machine Element															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEC401.1	Acquire an idea about engineering materials in machine design	2	2	3	-	-	2	2	1	2	1	-	2	2	-
MEC401.2	To learn the basic design procedure for	3	3	3	1	1	-	2	2	2	1	-	2	3	1

	different elementary machine elements														
MEC401.3	To learn about design of bolt and welded joints, pressure vessels etc.	3	3	3	1	2	-	2	2	2	1	-	2	3	2
MEC401.4	Introduction to fatigue design	2	3	3	1	-	-	-	1	-	1	-	3	3	-
Average		**2.5**	**2.8**	**3**	**0.8**	**0.8**	**0.5**	**1.5**	**1.5**	**1.5**	**1**	**-**	**2.3**	**2.8**	**0.8**

MEC402 : Casting, Forming and Welding

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEC402.1	Learn different types of casting process	3	2	3	1	-	2	1	-	-	2	-	3	2	1
MEC402.2	Select suitable manufacturing process for typical components.	3	2	2	2	-	2	1	-	-	2	-	3	3	1
MEC402.3	Learn the various welding process.	3	2	2	1	-	2	1	-	-	2	-	3	2	1
MEC402.4	Explain the concept of forging, rolling process and drawing.	3	2	3	1	-	2	1	-	-	2	-	3	2	1
Average		**3**	**2**	**2.5**	**1.2**	**-**	**2**	**1**	**-**	**-**	**2**	**-**	**3**	**2.2**	**1**

Couse Code and Course Name: MEC403, Heat and Mass Transfer

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEC403.1	Interpret the fundamental of heat and mass transfer	3	3	-	-	-	-	-	-	-	-	-	3	3	3
MEC403.2	Express the proficiency in handling laws of heat transfer	3	3	2	2	-	-	-	-	-	-	-	3	3	3
MEC403.3	Compute solutions for Heat transfer problems.	3	3	3	3	-	-	-	-	-	-	-	3	3	3
MEC403.4	Apply the laws of heat transfer in different Engineering problems.	3	3	3	3	-	-	-	-	-	-	-	3	3	3
MEC403.5	Evaluate the performance of heat transfer equipment.	3	3	3	3	-	-	-	-	-	-	-	3	3	3
MEC403.6	Design the heat exchangers.	3	3	3	3	-	-	-	-	-	-	-	3	3	3
Average		**3**	**3**	**2.3**	**2.3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**

Couse Code and Course Name: MES451, Solid Mechanics Laboratory

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MES451.1	Understand the concept of Mohr's circle for stress and strain, graphically	3	3	3	1	1	1	1	-	2	1	-	1	2	1
MES452.2	Analyze the behavior of the solid bodies subjected to tensile, impact and torsional loads	3	3	3	1	1	1	1	-	1	1	-	1	2	1
Average		**3**	**3**	**3**	**1**	**1**	**1**	**1**	**-**	**1.5**	**1**	**-**	**1**	**2**	**1**

Course Code and Course Name: MES452, Hydraulics Lab

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC452.1	To learn fundamentals of fluid mechanics	3	3	1	1	-	-	-	-	2	-	-	3	2	-
MEC452.2	To Measure various quantities viz. Volume flow rate, Cd, Friction factor	3	2	3	1	1	-	-	-	2	-	-	3	2	-
MEC452.3	To Calibrate of various quantities viz Venturimeter, Orificemeter and V-notch.	3	2	3	1	1	-	-	-	2	-	-	3	2	-
Average		**3**	**2.3**	**2.3**	**1**	**1**	**-**	**-**	**-**	**2**	**-**	**-**	**3**	**2**	**-**

Couse Code and Course Name: MES453, Mechanism Laboratory

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MES453.1	Students will be able to solve kinematics of mechanism by graphical method	3	1	1	-	1	-	-	-	-	-	-	2	2	1
MES453.2	Students will be able to analyze mechanism by computer aided tools	1	2	2	2	3	-	-	1	1	1	-	2	3	3
MES453.3	Students will be able to solve mechanism synthesis problems using computer aided tools	2	3	3	1	3	2	-	1	1	1	-	2	3	3
MES453.4	Students will be able to demonstrate model of few planar mechanisms	-	-	2	3	2	2	-	2	2	1	-	2	2	1
Average		**1.5**	**1.5**	**2**	**1.5**	**2.3**	**1**	**-**	**1**	**1**	**0.8**	**-**	**2**	**2.5**	**2**

Couse Code and Course Name: EEC-432, ELECTRICAL MACHINES

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
EEC432.1	Theory of electromechanical energy conversion, the concepts of voltage generation and fundamental torque equation.	3	3	3	3	2	1	1	1	2	3	2	1	-	1
EEC432.2	Basic understanding of the principles of operation and construction of direct and alternating current machines and transformers.	2	2	2	2	3	1	1	1	2	3	2	1	-	1
EEC432.3	A study of theory and concept of Electric Machines (AC & DC).	2	2	2	2	3	1	1	1	2	3	2	1	3	1
EEC432.4	Deriving equivalent circuit of electrical machines.	3	3	3	3	2	1	1	1	2	3	2	1	2	1
EEC432.5	Studying the performance and characteristics of Electrical machines (AC & DC).	3	3	3	3	2	1	1	1	2	3	2	1	1	-
Average		3	3	3	3	2	1	1	1	2	3	2	1	1.2	0.8

Couse Code and Course Name: EES-482, ELECTRICAL MACHINES LABORATORY

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
EES482.1	Ability to determine the equivalent circuit parameters of a single-phase transformer	3	3	3	3	2	1	1	1	2	3	2	1	1	-
EES482.2	Ability to determine the parameters of single-phase as well as three phase induction motor.	3	3	3	2	3	1	1	1	2	3	2	1	1	2
EES482.3	Ability to determine the characteristics of dc shunt generator and series generator	3	2	2	1	2	1	1	1	2	3	2	1	1	1
EES482.4	Ability to control the speed of a dc shunt motor	3	2	2	1	2	1	1	1	2	3	2	1	1	2
EES482.5	Ability evaluate the voltage regulation of an alternator	3	2	2	1	2	1	1	1	2	3	2	1	1	-
EES482.6	Ability to determine the efficiency of dc machines	3	2	2	1	2	1	1	1	2	3	2	1	1	1
Average		**3**	**2**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**3**	**2**	**1**	**1**	**1**

MEC501: Machining and Machine Tools

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC501.1	Knowledge of fundamental machining processes and the underlying science of machining and the related processes	3	2	1	2	-	-	-	-	-	-	-	2	1	1
MEC501.2	Various machine tools, their operations and the mechanisms in machine tools	1	1	3	3	3	2	2	1	-	-	-	1	3	1
Average		2	1.5	2	2.5	1.5	1	1	0.5	-	-	-	1.5	2	1

Couse Code and Course Name: MEC502, IC Engine and Gas Turbines

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC502.1	Interpret the fundamental of IC engines.	1		-	-	-	-	-	-	-	-	-			
MEC502.2	Express the proficiency in handling IC engine operations.	2				-	-		-	-	-	-	1		
MEC502.3	Solve problems of IC engines to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	2	3	2	3	2	-	2	-	-	-	-	2	2	
MEC502.4	Analyze the information by identifying causes, make inferences to support generalizations.	2	3	3	3	-	-		-	2	-	-	2	3	2
MEC502.5	Evaluate the performance of IC engines.	1	2	2		-	-		-	1	-	-	2	1	2
MEC502.6	Design IC engine components.	1	3	3		2	2	2	-	2	-	-	3	2	2
Average		**1.5**	**1.8**	**1.3**	**1**	**0.7**	**0.3**	**0.7**	**-**	**0.8**	**-**	**-**	**1.7**	**1.3**	**1**

MEC503 :: Machine Design

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC503.1	Detail analysis of members under fatigue loads.	2	1	3	1	2	3	2		3		-	2	2	
MEC503.2	Design procedures for some machine elements used in mechanical drives..	2	2	3	1	2	2	2				-	2	3	2

MEC503.3	Exposed to the importance of engineering tolerances and its use.	2	1	2	2	2	-	-				-	2	2	
MEC503.4	Introduction to different types of bearings and lubrications.	2	1	2	1	2	2	2				-	2	2	
MEC503.5	To understand the basics of gear mechanics.	2	1	3	1	3	3	2				-	2	1	
Average		**2**	**1.2**	**2.6**	**1.2**	**2.2**	**2.5**	**1.4**		**0.6**	**0**	**-**	**2**	**2**	**0.4**

Course Code and Course Name: MEC 504, Dynamics of Machinery

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEC504.1	Knowledge of gyroscopic motion of dynamic mechanical system.	2	2	2	2	1	1	1	-	-	-	-	2	2	2
MEC504.2	Knowledge of balancing of rotating and reciprocating machines.	2	2	2	3	1	1	2	-	-	-	-	2	2	2
MEC504.3	Knowledge of longitudinal, torsional and transverse vibration of mechanical system.	2	2	3	3	2	2	1	-	-	-	-	2	3	3
Average		2	2	2.3	2.7	1.3	1.3	1.3	-	-	-	-	2	2.3	2.3

Course Code and Course Name: MES 551, Design and Dynamics Laboratory

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES551.1	Acquire basic idea about the machine component drawing, geometric profiles of gears and cams.	1	3	3	2	-	-	-	-	2	-	-	1	2	2
MES551.2	To understand the use of gyroscope and governors.	1	3	3	2	-	-	-	-	2	-	-	1	2	2
MES551.3	Understanding vibratory systems and mass balancing concept.	1	3	3	2	-	-	-	-	2	-	-	1	2	3
Average		**1**	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**1**	**2**	**2**

Couse Code and Course Name: MES 552, Heat Transfer Laboratory

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES552.1	Fundamental concepts of Temperature measurement systems	3	2	1	2	-	-	-	-	2	1	-	1	-	1
MES552.2	Test on heat transferring apparatus	3	2	1	2	-	-	-	-	2	1	-	1	-	1

MES552.3	Knowledge on conduction heat transfer	3	2	1	2	-	-	-	-	2	1	-	1	-	1
MES552.4	Knowledge on convection heat transfer	3	2	1	2	-	-	-	-	3	1	-	1	-	1
MES552.5	Knowledge on Radiation heat transfer	3	2	1	2	-	-	-	-	3	1	-	1	-	1
Average		**3**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**2.4**	**1**	**-**	**1**	**-**	**1**

Couse Code and Course Name: MES553, CAD/CAM Laboratory

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES553.1	Able to learn geometric modelling using CAD tools	2	-	3	2	3	-	-	-	2	3	-	3	3	3
MES553.2	Able to use MATLAB for solving computer graphics problem and engineering analysis problem	3	-	2	1	3	-	-	-	2	1	-	2	3	3
MES553.3	Exposed to CNC part programming	1	-	2	-	3	-	-	-	2	1	-	2	2	2
Average		**2**	**-**	**2.3**	**1**	**3**	**-**	**-**	**-**	**2**	**1.7**	**-**	**2.3**	**2.7**	**2.7**

Couse Code and Course Name: WSS581, Workshop Practice- II

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
WSS581.1	Hands-on practice on Foundry	1		2		1	2			3	2		2	1	2
WSS581.2	Hands-on practice on different job manufacturing in machine shop	2		2		2	2			3	2		2	2	3
WSS581.3	Hands-on practice on Pattern Shop	1		2		1	2			3	2		2	1	2
WSS581.4	Hands-on practice on welding Shop	1		2		1	2			3	2		2	1	2
AVERAGE		**1.3**		**2**		**1.3**	**2**			**3**	**2**		**2**	**1.3**	**2.3**

Couse Code and Course Name: HSC631, Economics and Management Accountancy

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
HSC631.1	Learners will be able to review basic economic principles.	-	1	2		-	2			-	-	-	-	1	1
HSC631.2	Learners will be introduced to the basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or	-	3	2	1	-	-	-	1	1	3	3	2	1	2

	works														
HSC631.3	Learners will gain a good knowledge of financial accounting, enabling them prepare, analyse and interpret financial statements for taking informed decisions.	-	1	1	2	2	1	-	1	3	3	3	2	2	1
AVERAGE		**-**	**1.7**	**1.7**	**1**	**0.7**	**1**	**0.7**	**0.7**	**1.3**	**2**	**2**	**1.3**	**1.3**	**1.3**

Couse Code and Course Name: MEC601, Power Plant Engineering

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC601.1	Interpret the fundamental of power plant.	2		-	-	-	-	-	-	-	-	-			
MEC601.2	Express the proficiency in handling power plant equipment.	1				-	-		-		-	-			
MEC601.3	Solve problems of power plant.	3	3	3		-	1	1	-	1	-	1	1	2	1
MEC601.4	Analyze the information by identifying causes of failure, make inferences to support generalizations.	3	3	3	3	-	-	2	-	1	-	1	1	2	1
MEC601.5	Evaluate the performance of power plant.	3	2	2	3	-	-	3	-		-	1	2		1
MEC601.6	Design different power plant equipment	1		2	2	-	2	3	-	2	-	1	2	2	1
Average		**2.2**	**1.3**	**1.7**	**1.3**	**-**	**0.5**	**1.5**	**-**	**0.7**	**-**	**0.7**	**1**	**1**	**0.7**

Course Code and Course name : MEC602 , Industrial Engineering and Measurement

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC602.1	Knowledge on the structures of Engineering Organization in general.	2	1	2	1	1	3	-	3	1	3	3	2	2	1
MEC602.2	Planning of manning and production line.	2	3	3	3	1	2	-	1	1	2	3	1	2	2
MEC602.3	Ability for material management.	2	2	3	3	1	1	-	1	2	2	3	2	2	3
MEC602.4	Indian standards of measurement.	2	3	2	2	1	2	-	2	2	2	2	3	2	2
MEC602.5	Techniques of engineering measurements with its application.	2	3	3	3	1	2	-	1	1	2	3	2	3	3
Average		**2**	**2.4**	**2.6**	**2.4**	**1**	**2**	**-**	**1.6**	**1.4**	**2.2**	**2.8**	**2.2**	**2.2**	**2.2**

Couse Code and Course Name: MEE 610, Automobile Engineering

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE610.1	Explain the basic structures and working principles of different automobile	3	-	-	-	-	-	-	-	-	-	-	-	1	-

	components.														
MEE610.2	Calculate the power, performance heat transfers from engine.	3	3	2	3	-	-	3	-	-	-	-	-	2	-
MEE610.3	Design different automobile components	3	3	3	3	-	-	3	-	-	-	-	-	2	-
MEE610.4	Analyse the information by identifying causes of failure, make inferences to support generalizations.	3	3	3	3	-	3	3	-	-	-	-	3	3	-
Average		**3**	**2.3**	**2**	**2.3**	**-**	**0.8**	**2.3**	**-**	**-**	**-**	**-**	**0.8**	**2**	**-**

Couse Code and Course Name: MEE611, GAS DYNAMICS and PROPULSION

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE611.1	To learn compressible flows with constant entropy only, with friction only and with heat transfer only.	1	2	-	2	-	-	-	1	-	-	2	1	-	-
MEE611.2	To learn Normal shock, oblique Shock and Prandtl-Meyer Flow with real life applications.	1	-	-	2	3	-	-	1	-	-	2	2	1	2
MEE611.3	To learn Performance analysis of Air Breathing Engines (Ramjet, Turbojet (standard): Fan exhausted turbofan & Fan mixed turbofan and Turbo prop.)	1	-	2	2	3	-		1	-		3	3	1	2
MEE611.4	To learn Performance analysis of Non Air Breathing Engines (Solid Rocket Motors and Liquid Rocket Engines).	1	-	2	2	3	-		1	-		3	3	1	2
Average		**1**	**2**	**2**	**2**	**3**	**-**	**-**	**1**	**-**	**-**	**2.5**	**2.3**	**1**	**2**

COs	**MEE612: Mechanics of Forming and Press Working** **Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE612.1	Detailed and in depth analysis of the forming processes	2	3	3	1	2	1	1	-	-	-	-	2	2	-
MEE612.2	Specialized techniques in forming practiced in industry	-	1	3	-	-	2	-	-	-	-	1	-	2	2
Average		**1**	**2**	**3**	**0.5**	**1**	**1.5**	**0.5**	**-**	**-**	**-**	**0.5**	**1**	**2**	**1**

Course Name and Course Code: MEE613, Advanced Solids Mechanics

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE 613.1	Extend their knowledge from vector to tensor, and from isotropic to anisotropic materials	2	1	-	2	1	-	-	-	-	-	-	2	-	-
MEE 613.2	Apply the knowledge of 3-D state of stress and strain	2	3	3	3	2	-	-	-	1	-	-	3	3	3
MEE 613.3	Apply the concept of thick cylinder theory	2	1	3	3	1	-	-	-	-	-	-	2	3	3
MEE 613.4	Apply the energy principles	1	3	2	1	1				2	-	-	1	2	2
MEE 613.5	Apply the theory of noncircular shaft	1	1	3	3	1	-	-	-	2	-	-	1	-	-
Average		**1.6**	**1.8**	**2.2**	**2.4**	**1.2**	**-**	**-**	**-**	**1**	**-**	**-**	**1.8**	**1.6**	**1.6**

Couse Code and Course Name: MEE615, Operations Research

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE615.1	Students will be able to discuss the history, concepts, formulations and applications of operations research.	1	1	2	1	1	1	1	-	-	1	-	1	2	1
MEE615.2	Students will be able to analyze and solve conflicting problems on constrained linear optimization problems having single and multiple objectives.	2	2	3	1	1	1	1	-	-	1	1	1	2	1
MEE615.3	Students will be able to apply integer, dynamic programming methods for solving relevant problems.	3	3	3	1	1	1	1	-	-	1	-	1	2	1
Average		**2**	**2**	**2.7**	**1**	**1**	**1**	**1**	**-**	**-**	**1**	**1**	**1**	**2**	**1**

Course Code and Course name : MEE620 , Advanced Foundry Engineering

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE620.1	At the end of the course student will be able to get the knowledge about various aspects of casting processes and the underlying science	2	3	2	2	2	1	1	-	-	2	-	2	2	2

MEE620.2	To learn about various types of casting methods	2	2	3	3	2	1	3	-	-	2	-	3	3	3
MEE620.3	Application fields of various casting processes	2	1	3	2	1	1	1	-	-	-	-	2	2	1
Average		**2**	**2**	**2.6**	**2.3**	**1.6**	**1**	**1.6**	**-**	**-**	**2.3**	**-**	**2.1**	**2.3**	**2**

Couse Code and Course Name: MEE622, Engineering Optimization

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE622.1	Students will be able to describe and formulate optimization problems	1	1	2	1	1	1	1	-	-	1	-	1	2	1
MEE622.2	Students will be able to apply knowledge of different optimization methods for solving engineering problems	2	3	3	1	1	1	1	-	-	1	-	1	2	1
MEE622.3	Students will be able to differentiate between optimization methods and suggest a suitable technique applicable for a specific problem.	3	3	3	2	1	1	1	-	-	1	-	1	3	2
Average		**2**	**2.3**	**2.7**	**1.3**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**2.3**	**1.3**

Course Code and Course Name: MEE623, Multiphase flow and heat transfer

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE623.1	Understanding the principles of multi-phase flow and heat transfer.	3	2	2	3	3	-	-	-	-	-	-	2	2	3
MEE623.2	Relate the fluid-dynamic involved in convection and multi-phase heat transfer.	3	3	2	3	3	-	-	-	-	-	-	2	2	3
MEE623.3	Plan elementary analysis of most gas-liquid two-phase systems.	3	3	2	2	2	-	-	-	-	-	-	3	2	2
MEE623.4	Analyze the model to a wide variety of complex engineering problems.	3	3	2	2	2	-	-	-	-	-	-	2	2	2
MEE623.5	Conclude the Hydrodynamics of three phase flows and compare two phase flow situations.	3	3	2	2	2	1	-	-	-	-	-	2	2	2
Average		**3**	**2.8**	**2**	**2.4**	**2.4**	**1**	**-**	**-**	**-**	**-**	**-**	**2.2**	**2**	**2.4**

Couse Code and Course Name: MEE 624, Tribology															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE624.1	To learn the basic knowledge of surface topography and contact between engineering surfaces.	2	2	1			1						2	2	
MEE624.2	To learn the basic theory and application of friction and wear for different materials	2	2	1				1					2	2	
MEE624.3	To learn about lubricants and lubrication for different bearings	1	2	1									1	2	
MEE624.4	Introduced to Bio-tribology of human joints	1	2	2	2		3	2					3	2	2
MEE624.5	Introduced to Micro-tribology for MEMS applications	2	2	1	2		1	2					3	2	2
Average		**1.5**	**2**	**1.2**	**0.8**		**1**	**1**					**2.2**	**2**	**0.8**

MEE625 :: Computer Aided Design and Manufacturing															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE625.1	Able to understand scope and application of CAD/CAM tools in industry	1	-	2	-	3	-	-	2	2	1	-	3	3	3
MEE625.2	Able to learn geometric modelling and computer graphics concept in CAD tools	3	2	2	1	3	-	-	-	2	3	-	2	3	3
MEE625.3	Able to understand the different design analysis and optimization tools in CAD	3	3	2	1	3	-	-	-	2	2	-	2	3	3
MEE625.4	Able to understand the fundamentals of Additive manufacturing	1	1	1	-	3	-	1	2	1	-	-	2	3	3
Average		**2**	**1.5**	**1.8**	**0.5**	**3**	**-**	**0.3**	**1**	**1.8**	**1.5**	**-**	**2.3**	**3**	**3**

COs	**MES651: Engineering Measurement Laboratory**														
	Statement	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES651.1	Workshop and precision engineering measurement methods	3	1	-	-	2	-	-		3	3	1	2	2	1
MES651.2	Exposure to measuring instruments and their use	3	-	-	2	1	-	-	-	3	2	-	2	2	1
Average		**3**	**0.5**	**-**	**1**	**1.5**	**-**	**-**		**3**	**2.5**	**0.5**	**2**	**2**	**1**

Couse Code and Course Name: MES 652, Power Generation Laboratory															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES652.1	Experimentation of refrigerating systems	3	3	3	3	-	-	-	-	3	-	-	-	1	1
MES652.2	Experimentation on steam generators	3	3	3	3	-	-	-	-	3	-	-	-	1	1
MES652.3	Study of steam turbines	3	3	3	3	-	-	-	-	3	-	-	-	2	1
MES652.4	Test on diesel engine	3	3	3	3	-	-	-	-	3	-	-	-	2	1
MES652.5	Experimentation on steam nozzle	3	3	3	3	-	-	-	-	3	-	-	-	2	1
Average		**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**-**	**-**	**-**	**1.6**	**1**

Couse Code and Course Name: MES653, Machine Design Sessional-I															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES653.1	Acquire basic idea about making the design and production drawing for simple and common mechanical assembly	2	3	3	-	3	-	1	2	2	3	-	3	3	3
MES653.2	To understand the method of implementation of engineering tolerances	1	2	3	-	2	2	1	2	2	2	-	2	3	1
MES653.3	To identify the importance of using the standards and use of catalogues in making the design	-	-	2	-	2	2	1	1	2	1	-	2	3	2
AVERAGE		**1**	**1.7**	**2.7**	**-**	**2.3**	**1.3**	**1**	**1.7**	**2**	**2**	**-**	**2.3**	**3**	**2**

Course Code and Course name : MES654 , Manufacturing Laboratory															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES654.1	Hands on practice on different job manufacturing by milling machine	3	2	2	2	-	2	-	-	3	2	1	1	3	1
MES654.2	Understanding power transmission mechanism in lathe, drilling machine, Milling machine etc.	3	3	2	1	-	1	-	-	1	2	1	3	3	1
MES654.3	Exposure to grinding machine and job practice	3	2	2	2	-	1	-	-	1	2	2	3	3	1
MES654.4	Exposure to NC/CNC machines, part programming, and job practice	3	2	2	1	-	1	-	-	1	2	2	3	3	3
MES654.5	Job practice in nonconventional machining, ECM, EDM etc.	3	2	2	2	-	2	-	-	3	2	1	1	3	3
Average		**3**	**2.2**	**2**	**1.6**	**-**	**1.4**	**-**	**-**	**1.8**	**2**	**1.4**	**2.2**	**3**	**1.8**

Couse Code and Course Name: MSC731, PRINCIPLES OF MANAGEMENT															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MSC731.1	To make budding engineers aware of various management functions required for any organization									3	2	2	1	1	
MSC731.2	To impart knowledge on various tools and techniques applied by the executives of an organization				2					2	2		1	2	1
MSC731.3	To make potential engineers aware of managerial function so that it would help for their professional career				2					3	2	2	2	2	1
MSC731.4	To impart knowledge on organizational activities operational and strategic both in nature							1		3	3	1		2	1
MSC731.5	To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science				2			1		2	2	3	1	2	2
AVERAGE					**1.2**			**0.4**		**2.6**	**2.2**	**1.4**	**1**	**1.8**	**1**

Course Name and Course Code: MEE710, Finite Element Methods															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE710.1	To obtain an understanding of the fundamental theory of the FEA method	3	1	--	--	--	--	2	--	2	--	---	2	1	1
MEE710.2	To develop the ability to generate the governing FE equations for systems governed by partial differential equations	2	1	2	3	1	1	1	--	2	---	---	2	3	2
MEE710.3	To understand the use of the basic finite elements for analysis of bar, truss, beam etc.	2	1	3	3	1	1	1	--	2	---	---	2	3	2
Average		**2.3**	**1**	**1.7**	**2**	**0.7**	**0.7**	**1.3**	**-**	**2**	**-**	**-**	**2**	**2.3**	**1.7**

Couse Code and Course Name: MEE711, COMPUTATIONAL FLUID DYNAMICS and HEAT TRANSFER															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE711.1	To learn to model a physical Fluid Mechanical and Heat Transfer problem (both Laminar & Turbulent Flow) mathematically in terms of PDEs.	1	2	-	-	-	-	-	1	-	-	2	1	1	-
MEE711.2	To learn discretization of the PDEs using Finite Difference and Finite Volume Methods	3	-	-	2	-	-	-	1	2	-	-	-	1	-
MEE711.3	To learn R-K4 method to solve ODEs and Techniques to solve PDEs.	3	-	-	2	3	-		1	2		-	-	1	2
MEE711.4	To learn to solve simple Heat transfer Problems and Viscous Incompressible Fluid Flow problems using MATLAB coding and checking the same by simulation using ANSYS-Fluent software	1	2	-	2	3	-		1	-		3	3	1	2
Average		**2**	**2**	**-**	**2**	**3**	**-**	**-**	**1**	**2**	**-**	**2.5**	**2**	**1**	**2**

	MEE713: Nonconventional Machining														
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE713.1	Cutting edge technology for nonconventional/ precision machining	1	3	2	2	1	1	-	-	-	-	-	2	2	1
MEE713.2	Emerging trends of metal removal processes	1	1	3	3	3	2	2	2	-	-	-	2	1	2
Average		**1**	**2**	**2.5**	**2.5**	**2**	**1.5**	**1**	**1**	**-**	**-**	**-**	**2**	**1.5**	**1.5**

Course Code and Course name : MEE714 , Advanced Welding Technology															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE714.1	To get the knowledge about newly developed welding process and its parameters	3	3	1	1	2	1	3	-	-	2	-	3	2	2
MEE714.2	To learn various nonconventional welding methods	3	2	3	3	2	1	3	-	-	2	-	3	3	3
MEE714.3	To learn various application fields of various welding processes	3	1	3	2	1	1	1	-	-	-	-	3	2	1
Average		**3**	**2**	**2.3**	**2**	**1.6**	**1**	**2.3**	**-**	**-**	**2.3**	**-**	**3**	**2.3**	**2**

Couse Code and Course Name: MEE715, Robotics

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE715.1	Students will be able to discuss the history, concepts and key components of robotics technologies	1	1	2	1	1	1	1	-	-	-	-	1	1	1
MEE715.2	Students will be able to analyse and solve problems spatial transformation, forward and inverse kinematics, dynamics of robot manipulators, jacobian and singularities, joint trajectory for motion planning	2	3	3	1	2	1	1	1	1	1	-	1	2	1
MEE715.3	Students will be able to describe and compare various robot grippers, sensors, actuators and controllers and their perception	1	1	1	1	1	1	1	-	-	1	-	1	1	1
Average		**2**	**2.3**	**2**	**1**	**1.3**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**1.7**	**1**

Couse Code and Course Name: MEE717, Control Systems

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE717.1	Will get exposure to the block diagram based formulations, behavior of linear time continuous control systems.	1	1	1	1	1	1	1	-	-	-	-	1	1	1
MEE717.2	Ability to analyze the system performance and relative stability information.	2	3	3	1	2	1	1	-	1	1	-	1	2	1
MEE717.3	Understand the relevance of characteristic roots in the behavior of various dynamic systems.	2	3	3	1	2	1	1	-	1	1	-	1	2	1
MEE717.4	Ability to design simple controllers for analog systems.	2	3	3	1	2	1	1		1	1	-	1	2	1
MEE717.5	To study and analyze state space methods, controllability and observability of control systems.	2	3	3	1	2	1	1	-	1	1	-	1	2	1
Average		**1.8**	**2.6**	**2.6**	**1**	**1.8**	**1**	**1**		**0.8**	**0.8**	**-**	**1**	**1.8**	**1**

Couse Code and Course Name: MEE721, Convective Heat and Mass Transfer															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE721.1	To acquire an idea about convective transport mechanism	3	3	2	-	1	1	-	-	-	-	-	-	3	1
MEE721.2	To learn the basics of convective heat and mass transfer	3	3	2	-	2	-	-	-	-	-	-	-	3	1
MEE721.3	To learn about internal and external convection	3	3	3	2	2	-	-	-	-	-	-	2	3	2
MEE721.4	To learn about forced and natural convections	3	3	3	2	2	-	-	-	-	-	-	2	3	2
MEE721.5	To learn about heat transfer in phase change	3	3	2	2	1	1	-	-	-	-	-	2	3	2
Average		**3**	**3**	**2.4**	**1.2**	**1.6**	**0.4**	**-**	**-**	**-**	**-**	**-**	**1.2**	**3**	**1.6**

MEE722 :: Additive Manufacturing															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE722.1	Able to understand the principles of different additive manufacturing processes	3	-	2	-	3	-	-	-	-	-	-	3	3	2
MEE722.2	Able to learn softwares for additive manufacturing	2	2	2	2	3	-	-	-	-	-	-	2	3	3
MEE722.3	Able to expose materials for Additive Manufacturing and it’s selection	2	-	2	-	-	-	-	-	-	-	-	2	3	2
MEE722.4	Able to know areas of usage, possibilities and limitations of the additive manufacturing technologies	2	2	2	2	2	-	2	1	-	-		2	3	2
Average		**2.3**	**1**	**2**	**1**	**2**	**-**	**0.5**	**0.3**	**-**	**-**	**-**	**2.3**	**3**	**2.3**

Course Code and Course Name: MEE724, Hydraulic Machines															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE 724.1	Knowledge of Hydraulic Machines	3	2	1	1	1	1	2	1	1	-	1	2	2	1
MEE 724.2	Selection of Turbines and Pumps	3	3	2	1	1	1	2	1	1	-	1	1	3	1
Average		**3**	**2.5**	**1.5**	**1**	**2**	**1**	**2**	**1**	**1**	**-**	**1**	**1.5**	**2.5**	**1**

Course Code and Course Name: MES 751, Hydraulic Machine Lab

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC751.1	To understand the principle of linear momentum	3	2	2	1	-	-	1	1	-	-	-	2	3	-
MEC751.2	To understand the performance characteristics of various pumps.	3	3	2	1	-	-	1	-	2	-	-	2	2	-
MEC751.3	To understand the performance characteristics of various turbines.	3	3	2	1	-	-	1	-	2	-	-	2	2	-
Average		**3**	**2.7**	**2**	**1**	**-**	**-**	**1**	**0.3**	**1.3**	**-**	**-**	**2**	**2.3**	**-**

Couse Code and Course Name: MES752, Machine Design Sessional-II

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MES752.1	Acquire basic idea about making the design and production drawing for relatively complicated mechanical systems for example gear boxes.	3	3	3	-		1	1	2	2	2	-	3	3	3
MES752.2	To understand the method of implementation of engineering tolerances.	1	2	3	-	1	1	1	2	2	1	-	2	3	1
MES752.3	To learn about economic design procedures.	2	2	3	-	1	1	1	1	2	1	-	2	3	2
AVERAGE		**2**	**2.3**	**3**	**-**	**0.7**	**1**	**1**	**1.7**	**2**	**1.3**	**-**	**2.3**	**3**	**2**

Couse Code and Course Name: MES753, Vocational Training /Summer Internship and Seminar

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MES753.1	Exposer to the professional world of engineering and research			1			3		1	3	3		3		
MES753.2	Interaction with the people of related field and community at large	2	2		2		3		1	3	3		3		1
MES753.3	Correlation of the theoretical knowledge with the application	3	3	2	2				1				2	3	2
MES753.4	Learning of technical report writing.				1					2	3		2	2	
MES753.5	Learning the way of oral presentation to audience.						1			2	3		2	1	
AVERAGE		**1**	**1**	**0.6**	**1**		**1.4**		**0.6**	**2**	**3**		**2.4**	**1.2**	**0.6**

Couse Code and Course Name: MES754, Project-I

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MES754.1	Identification of Industrial/ Academic/ Engineering Problem	3					2	2		3	2			1	
MES754.2	To identify and utilize relevant previous work that supports their selected project problem.	3	3		3					3	2		3	1	1
MES754.3	Identification and application of appropriate methodologies to solve the project problem.		3	3	2	3	1	2	2	3	2	2	2	2	2
MES754.4	Formulation of the problem solution method and timeline.		3	3	2	3		2	2	3	2	1	2	2	3
MES754.5	Meet the relevant field's standards	3				2	2	1	1				3	2	1
MES754.6	Project report writing									3	3	1	2	1	1
AVERAGE		**1.5**	**1.5**	**1**	**1.2**	**1.3**	**0.8**	**1.2**	**0.8**	**3**	**1.8**	**0.7**	**2**	**1.5**	**1.3**

Couse Code and Course Name: MEE810, Solar Energy

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE810.1															
MEE810.2															
MEE810.3															
MEE810.4															
Average															

Couse Code and Course Name: MEE811, Mechatronics

COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE811.1	Students will be able to identify the importance of amalgamation between the electronics and electro-mechanical systems.	1	1	1	1	1	1	1	-	-	-	-	1	1	1
MEE811.2	Students will be able to formulate and evaluate behavior of linear time continuous control systems.	2	3	3	1	2	1	1	-	1	1	-	1	2	1
MEE811.3	Students will be able to formulate the procedure for converting analog signals to digital form and vice-versa.	2	2	2	1	1	1	1	-	1	1	-	1	1	1

MEE811.4	Students will be able to describe signals and its processing by modern electronic methods.	2	2	2	1	2	1	1	1	1	1	-	1	1	1
MEE811.5	Students will be able to identify and critically evaluate current developments and emerging trends within the field of mechatronic systems.	1	1	1	1	1	1	1	-	1	1	-	1	1	1
Average		**1.6**	**1.8**	**1.8**	**1**	**1.4**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**1.2**	**1**

Course Code and Course name : MEE812 , Micro and Nano Manufacturing															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE812.1	To understand the need for micro and nano scale fabrication	3	1	1	1	2	3	3	2	-	1	-	3	3	1
MEE812.2	To get acquainted with different micro and nano scale fabrication techniques and their characterization	3	3	3	3	3	2	1	1	-	2	-	3	2	2
MEE812.3	To be able to select a suitable micro or nano scale fabrication process based upon the requirement	3	3	3	3	3	3	3	2	-	3	-	3	3	3
MEE812.4	To compare and understand the differences between macro and nano scale fabrication processes	3	2	2	2	3	3	3	1	-	-	-	3	2	3
Average		**3**	**2.2**	**2.2**	**2.2**	**2.7**	**2.7**	**2.5**	**1.5**	**-**	**2.2**	**-**	**3**	**2.5**	**2.2**

Course Code and Course Name: MEE813, Microfluidics															
COs	**Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
MEE813.1	To learn micro channel flows with heat transfer.	3	2	2	2	3	3	2	-	2	2	3	2	3	3
MEE813.2	To learn Surface Tension Driven Flows with real life applications.	3	3	2	3	2	3	3	-	2	2	3	3	2	3
MEE813.3	To learn Electro-hydro-dynamics fundamentals	3	3	3	3	2	3	3	-	2	2	3	3	3	3
MEE813.4	To learn Molecular Dynamics Simulations	3	2	2	3	2	2	3	-	2	3	2	3	3	3
Average		**3**	**2.5**	**2.3**	**2.8**	**2.3**	**2.8**	**2.8**	**-**	**2**	**2.3**	**2.8**	**2.8**	**2.8**	**3**

	MEE814: Machine Tool Engineering and Automation

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEE814.1	In depth study of mechanical machine tools construction and design	3	2	2	2	1	-	1	1	-	-	-	1	2	1
MEE814.2	Introduction to machine tools automation	2	2	2	3	2	1	2	2	-	-	2	2	3	2
Average		**2.5**	**2**	**2**	**2.5**	**1.5**	**0.5**	**1.5**	**1.5**	**-**	**-**	**1**	**1.5**	**2.5**	**1.5**

Course Code and Course Name: MEE 816, Advanced Mechanical Vibration

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEC816.1	Understanding the fundamental material for a modern treatment of vibrations.	2	2	1	2	1	1	1	-	-	-	-	2	2	2
MEC816.2	Application of Lagrange equations for lumped and continuous systems	2	2	3	3	2	1	1	-	-	-	-	2	2	3
MEC816.3	Understanding fundamentals of beam theory; extensional, torsional, and flexural vibrations of beams.	2	2	3	2	2	2	1	-	-	-	-	2	3	2
MEC816.4	Understanding Self-excited vibration, nonlinear vibration etc.	2	2	3	3	1	2	1	-	-	-	-	2	3	3
Average		**2**	**2**	**2.5**	**2.5**	**1.5**	**1.5**	**1**	**-**	**-**	**-**	**-**	**2**	**2.5**	**2.5**

Couse Code and Course Name: MEO 841, NONLINEAR DYNAMICAL SYSTEMS

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEO 841.1	To learn stability analysis of nonlinear transient problems in all fields.	2	2	-	2	-	-	-	1	2	-	2	1		
MEO 841.2	To learn Chaos of nonlinear transient problems using dynamical behaviors (Bifurcations, FFT, Poincare Maps, Lyapunav exponents, Henon maps and Fractals)	2	-	-	2	-	-	-	1	2	-	2	1		-
Average		**2**	**1**	**-**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**2**	**1**		**-**

Couse Code and Course Name: MES851, Project-II

COs	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MES851.1	Review of project-I	2		2				1		2	1		1	1	
MES851.2	Addition literature survey on selection of the methodology	2	1	2	1		1	1	2	3	1		1	1	

MES851.3	Solution of the selected problem by using soft tools/ simulation/ model making	1	3	3	3	3		1		3	2		2	3	3
MES851.4	To meet the relevant field's standards	3	2	3			2	2	1	1	1	2	2	2	2
MES851.5	Analysis of the solution to arrive at the conclusion	1	3	2	3	2	2	1	2	2	1	2	2	2	3
MES851.6	Thesis writing in standard format.								1	3	3		2	1	1
AVERAGE		**1.5**	**1.5**	**2**	**1.2**	**0.8**	**0.8**	**1**	**1**	**2.3**	**1.5**	**0.7**	**1.7**	**1.7**	**1.5**

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN METALLURGICAL AND MATERIALS ENGINEERING

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in _____ Senate # ______________ # Item no: ______

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Program Name: Bachelor of Technology in Metallurgical and Materials Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR METALLURGICAL AND MATERIALS ENGINEERING - B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics- III	3	1	0	4.0	4
2	MMC301	Metallurgical Thermodynamics and Kinetics	3	1	0	4.0	4
3	MMC302	Introduction of Metallurgy and Materials	3	1	0	4.0	4
4	MMC303	Non - Ferrous Process Metallurgy	3	1	0	4.0	4
5	ESC332	Economic Geology	3	0	0	3.0	3
6	ESS382	Economic Geology Laboratory	0	0	3	1.5	3
7	MMS351	Metallurgical Thermodynamics and Kinetics Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**4**	**6**	**22.0**	**25**

Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MMC401	Transport Phenomena in Metallurgical Processes	3	1	0	4.0	4
2	MMC402	Phase Transformation and Phase Equilibria	3	1	0	4.0	4
3	MMC403	Materials Characterization	3	1	0	4.0	4
4	YYO44*	Open Elective - I	3	0	0	3.0	3
5	CSC433	Data Structures	3	0	0	3.0	3
6	CSS483	Data Structures Laboratory	0	0	3	1.5	3
7	MMS451	Transport Phenomena Laboratory	0	0	3	1.5	3
8	MMS452	Phase Transformation and Phase Equilibria Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**3**	**9**	**22.5**	**27**

Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MMC501	Manufacturing Processes	3	1	0	4.0	4
2	MMC502	Heat Treatment of Materials	3	1	0	4.0	4
3	MMC503	Fundamentals of Plastic Deformation and Strengthening of Materials	3	1	0	4.0	4
4	MMC504	Iron Making	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	MMS551	Manufacturing Processes Laboratory - I	0	0	3	1.5	3
7	MMS552	Heat Treatment of Materials Laboratory	0	0	3	1.5	3
8	MMS553	Plastic Deformation and Strengthening of Materials Laboratory	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**4**	**9**	**23.5**	**28**

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	MMC601	Steel Making	3	1	0	4.0	4
3	MMC602	Mechanical Working of Materials	3	0	0	3.0	3
4	MME610 --	Depth Elective - 1	3	0	0	3.0	3
5	MME610 --	Depth Elective - 2	3	0	0	3.0	3
6	MMS651	Mineral Beneficiation Laboratory	0	0	3	1.5	3
7	MMS652	Mechanical Working of Materials Laboratory	0	0	3	1.5	3
8	MMS653	Material Characterization Laboratory -I	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	1	9	20.5	25
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	MME710 --	Depth Elective - 3	3	0	0	3.0	3
3	MME710 --	Depth Elective - 4	3	0	0	3.0	3
4	MME710 --	Depth Elective - 5	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	MMS751	Manufacturing Processes Laboratory - II	0	0	3	1.5	3
7	MMS752	Material Characterization Laboratory -II	0	0	3	1.5	3
8	MMS753	Ferrous Process Metallurgy Laboratory	0	0	3	1.5	3
9	MMS754	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
10	MMS755	Project - I	0	0	3	1.0	3
		TOTAL	15	0	14	21.5	29
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MME810 --	Depth Elective - 6	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	MMS851	Project - II	0	0	15	5.0	15
5	MMS852	Project Seminar	0	0	0	1.0	0
6	MMS853	Viva Voce	0	0	0	1.0	0
		TOTAL	9	0	15	16.0	24

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45.0	22.0	22.5	23.5	20.5	21.5	16.0	171.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MME610	Engineering Materials
MME611	Electronic and Thermal Properties of Materials
MME612	Alternative Routes of Iron Making
MME613	Production of Ferroalloys
MME615	Ceramic Technology
MME616	Solidification Phenomena
MME617	Metal Joining Processes

7th Semester

	DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MME710	Functional Materials
MME711	Fatigue, Creep and Fracture
MME712	Computational Materials Engineering
MME713	Fuel, Furnace and Refractories
MME714	Powder Metallurgy
MME715	Secondary Steel Making
MME716	Composite Materials
MME717	Corrosion Engineering
MME718	Energy and Environment in Metallurgical Industries

8th Semester

	DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MME810	Nano Science and Technology
MME811	FEM Modelling and Simulation for Materials Design
MME812	Mathematical Modelling and Simulation
MME813	Raw Materials Preparation for Iron and Steel Making

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's						

	ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal						

	propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
None	CT+MT+EA

Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4)

	iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free

	body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues.						

	• CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of						

	points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2)						

	10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.						
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnometry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil						
	<u>Suggested Text Books:</u> 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra <u>Suggested Reference Books:</u> 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)#**	**Total Hours**	
WSS51	**WORKSHOP PRACTICE**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Study and practice on machine tools and their operations • CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding • CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping • CO4: Develop basic electrical engineering knowledge for house wiring practice
Topics Covered	**M/c shop & Carpentry shop -- 3X3= 9hrs.** • Introduction on machining process. • Introduction to machine tools- Lathe, Shaper, Milling and Drill machine. • Introduction to woods- Types, structure, disease and defect of wood. • Introduction to wood working machines and tools. • Making of dovetail joint and bridle joint. **Welding Shop & Sheet metal -- 3X3= 9hrs.** • Introduction to welding.Safety and precautions in welding. • Formation of weld bead by SMAW on mild steel flat. • Formation of weld bead by oxy-fuel welding on mild steel flat. • Introduction to sheet Metal works. • Tools and Machines used in sheet metal works. • Concept of development, marking out of metal sheets. • Cutting and joining of metal sheets. • Safety precautions, General warning needed in the shop floor. **Black smithy & Foundry -- 3X3= 9hrs.** • Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels. • Safety and precautions in blacksmithy. • Making of bars of different cross-sections. • Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology.

	• Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	Co-curricular Activities	PCR	0	0	2	2	1
Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))						
NIL	CT+EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics	YOGA						

Covered	• Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET**

- Introduction of Cricket
- Batting gripping & Stance, Bowling gripping technique.
- Batting front foot defense& Drive.
- Batting Back foot defense& Drive.
- Batting Square cut.
- Bowling medium pace, Bowling off break.
- Fielding drill, Catching (Short & High).
- Rules & Regulation.

BADMINTON

- Basic introduction about Badminton and Badminton court.
- Racket parts, Racket Grip, Shuttle Grip.
- Basic stance, Basic Footwork, Shadow practice (Full court movement).
- Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm.
- Match practice (Single & Double).
- Rules & Regulation.

TABLE TENNIS

- Introduction of Table Tennis.
- Basic Stance and Grip (Shake hand & Pen hold).
- Service Basic.
- Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Rules and their interpretations.
- Table Tennis Match (Singles & Doubles).

NCC

- FD-1 General Introduction and words of command.
- FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt.
- FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing.
- FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out.
- FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt.
- FD-7 Turning on the March and Wheeling.
- FD-12 Parade practice.

TAEKWONDO

- Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc.
- Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc.
- Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc.
- Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc.

NSS

- Swachha Bharat Mission

	• Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAC 02</td><td>MATHEMATICS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic concepts of set theory, differential equations, and probability.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
• CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
• CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
• CO4: To grasp the basic concepts of probability theory.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Elementary algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (5)
Linear Algebra: Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)
Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions,</td></tr>
</table>

	Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4) **Laplace and Fourier Transforms:**Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10^{th}ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3^{rd} Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems						

	CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC01</td><td>Basic Electronics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">(10+2) level mathematics and physics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
• CO1: Knowledge of Semiconductor physics and devices.
• CO2: Have an in depth understanding of basic electronic circuit, construction, operation.
• CO3: Ability to make proper designs using these circuit elements for different applications.
• CO4: Learn to analyze the circuits and to find out relation between input and output.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
1. Semiconductors
1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium
1.2. Definitions of insulator, conductor and semiconductor using band diagram
1.3. Crystalline structure of semiconductor
1.3.1. Covalent bond
1.3.2. Generation of holes and electrons
1.3.3. Effect of temperature on semiconductor
1.4 Intrinsic semiconductor
1.5 Doping and Extrinsic semiconductor
1.5.1 n-Type semiconductor and band diagram
1.5.2 p-Type semiconductor and band diagram
1.5.3 Mass-action law of semiconductor
1.6. Conductivity of semiconductor (including mathematical expression)
1.7 Carrier transport phenomenon. (03 hrs.)
2. Diodes
2.1. Construction
2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only)
2.3. Principle of operation with forward biasing and reverse biasing
2.4. Characteristics
2.5 Diode’s three models/equivalent circuits.(02 hrs.)
3.Diode Circuits
3.1 Diode rectifier
3.1.1 Half wave rectifier
3.1.2 Full wave rectifier:centre tap and bridge rectifier
3.1.3 Capacitive filter and DC power supply (Numerical problems)
3.2 Special Diodes
3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics.
3.2.2 Zener diode as a voltage regulator
3.2.3 Displaydevices: LED and LCD. (03 hrs.)
4.Bipolar Junction Transistor (BJT)</td></tr>
</table>

	4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01

	hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	ELECTRICAL TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))					
NIL		CT+MT+ EA					
Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts. • CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's • CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts. • CO4: introduce the basic concept of single-phase transformer. • CO5: analyze the transient phenomena in electrical circuits with DC excitation.						

Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism.						

	CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon,

	packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India.						

	CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output signals.						
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.						
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA
Course Outcomes	• CO1: understand the principle of superposition. • CO2: understand the principle of maximum power transfer • CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: understand the calibration of energy meter. • CO5: understand open circuit and short circuit test of single-phase transformer. • CO6: analyze RLC series and parallel circuits • CO7: understand three phase connections. • C08: understand determination of B-H curve
Topics Covered	**List of Experiments:** 1. To verify Superposition and Thevenin's Theorem. 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit 9. Determination of B-H Curve for magnetic material
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma , H U Ezea 2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3

CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)#**	**Total Hours**	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting.						

	• Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service. • Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations.

- Table Tennis Match (Singles & Doubles).

NCC

- FD-6 Side pace, Pace Forward and to the Rear.
- FD-7 Turning on the March and Wheeling.
- FD-8 Saluting on the March.
- FD-9 Marking time, Forward March and Halt in Quick Time.
- FD-10 Changing step.
- FD-11 Formation of Squad and Squad Drill.
- FD-12 Parade practice.

TAEKWONDO

- Poomsae (Forms)- Jang, Yi Jang.
- Self Defense Technique- Self defense from arms, Fist and Punch.
- Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring).
- Combination Technique- Combined kick and punch.
- Board Breaking (Kyokpa)- Sheet breaking.
- Interpretation Rules above Technique of Taekwondo.

NSS

- No Smoking Campaign
- Anti- Terrorism Day Celebration
- Any other observation/celebration proposed by Ministry/institute
- Public Speaking
- Discussion on Current Affairs
- Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CO-PO Mapping and Matrix

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	3	3	1	2	-	-	-	-	1	-	-	-
	CO2	3	3	1	2	-	-	-	-	1	-	-	-
	CO3	3	3	1	2	-	-	-	-	1	-	1	1
	CO4	3	-	-	2	-	2	-	-	1	-	-	-
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1
CYC01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-

	CO4	-	1	-	-	2	-	1	-	-	-	-	-
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-
MAC02	CO1	2	3	1	3	-	-	-	-	2	-	-	-
	CO2	2	3	1	2	-	-	-	-	2	-	-	-
	CO3	2	2	2	3	2	-	-	-	3	-	1	1
	CO4	2	3	2	3	2	1	1	-	2	-	-	-
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-
ECC01	CO1	-	-	-	-	-	-	-	-	-	-	-	-
	CO2	-	-	-	-	-	-	-	-	-	-	-	-
	CO3												
	CO4	-	-	-	-	-	-	-	-	-	-	-	-
EEC01	CO1	3	1	-	-	2	-	-	-	-	1	-	-
	CO2	2	3	2	-	2	-	-	-	-	-	-	-
	CO3	2	3	1	-	-	-	-	-	-	1	-	-
	CO4	3	1	2	-	1	-	-	-	-	-	-	-
	CO5	3	1	2	-	1	-	-	-	-	-	-	-
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-

	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-
	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
XES52	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-
	CO1	3	-	1	-	-	-	-	-	-	-	-	-
CSS51	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-
	CO1	3	2	1	2	2	1	-	-	2	-	-	-
ECS51	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-
	CO1	3	-	2	-	3	-	-	-	1	-	-	-
	CO2	3	-	2	-	3	-	-	-	1	-	-	-
	CO3	2	3	2	2	1	-	2	-	1	-	-	-
EES51	CO4	2	3	1	2	2	-	1	-	1	1	-	-
	CO5	2	3	1	2	2	-	-	-	1	-	-	-
	CO6	2	3	2	2	2	-	-	-	1	-	-	-
	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
XXS51	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-
	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
XXS51	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

THIRD SEMESTER

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	**Mathematics- III**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of topics included in MAC01 & MAC02		CT+MT+EA					
Course Outcomes	• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. • CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. • CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. • CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.						
Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]						
Text Books, and/or reference material	**Text Books:** 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami						

	4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1	2	-	-	-	-	2
CO2	3	3	2	2	2	1	2	-	-	-	1	2
CO3	3	3	2	2	3	-	1	-	-	1	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC301	Metallurgical Thermodynamics and Kinetics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CYC01: Engineering Chemistry		CT+MT+EA					
Course Outcomes	CO1: Acquire the knowledge of thermodynamic laws to apply in metallurgical processes and materials. CO2: Identify the feasibility of metallurgical processes and reactions. CO3: Learn to analyze the kinetics of metallurgical processes and design the alloy systems by applying the concepts of thermodynamics.						
Topics Covered	Definitions, behaviour of gasses, vapours and gaseous moisture, materials balances in metallurgical processes. (4) First law of thermodynamics, Heat and work changes in reversible processes, Concept of Heat Capacity, Enthalpy energy balance in metallurgical processes, Reversible adiabatic process. (4) The Carnot cycle, concept of entropy, Entropy changes in reversible, irreversible processes and universe, Clausius inequality, Combined statement of first and second law, Entropy change for irreversible chemical reactions. (6) Helmholtz free energy and the Gibbs free energy, Free-energy equations in differential form, Thermodynamic potentials, The Maxwell relations, Criteria of equilibrium and spontaneity (or irreversibility), The Gibbs-Helmholtz equation, Third law of thermodynamics. (6) Concept of chemical potential, Chemical potential of oxygen, partial molar quantities, Integral molar quantities, Raoult's law and Henry's law, Alternative standard states,Sievert's law, Mixing function, Excess function, Regular solution, concept of interaction parameter. (13)						

	Fugacity, Activity, standard state, equilibrium constant, Van't Hoff reaction isotherm,Le Chatelier's Principle, Free-energy Charts and Ellingham diagrams, Gas-solid reaction, Van't Hoff equation, Sigma Function (Σ), Clausius-Clapeyron Equation, Trouton's Rule. (8) Types of electrochemical cells, Laws of electrolysis, determination of thermodynamics quantities using reversible electrochemical cells, Electrochemical cell based on solid electrolytes. (3) Types of reaction, Order of reaction, Determination of order and rate constant of a reaction. (6)
Text Books, and/or reference material	Suggested Text Books: 1. Introduction to Metallurgical Thermodynamics – David R Gaskell. 2. Metallurgical 2. Textbook of Materials and Metallurgical Thermodynamics –A. Ghosh 3. Thermochemistry – O. Kubaschewski, E LL Evans and C B Alcock Suggested Reference Books: 1. Stoichometry and thermodynamics of Metallurgical processes - Y K Rao. 2. Problems in Metallurgical Thermodynamics and Kinetics – G S Upadhyay and R K Dube. 3. Chemical Kinetics - Keith Laidler.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	1
CO2	2	3	1	1	1	1	1	1	1	1	1	1
CO3	1	2	3	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC302	Introduction to Metallurgy and Materials	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
PHC01: Engineering Physics		CT+EA					

Course Outcomes	I. To correlate atomic structure, periodic table, elemental properties, chemical bonding and material properties. II. To interpret crystal structure in view of translational periodicity and symmetry and as well as to introspect different kinds of defects in a crystal. III. To study the binary phase diagrams and a brief introduction to different engineering materials.
TopicsCovered	Atomic Structure and chemical Bonding: Quantum mechanical approach, Schrödinger wave equation, wave function, Quantum state, Periodic Table, electronic configuration and atomic structure. Bonding in solids, different types

	of bonds, Bond energy, effect of bonding on material properties. (10) Structure of Solids: The crystalline and the noncrystalline states – Metals and Alloys,Ceramics,semiconductorsandpolymers;Crystalstructure–conceptoflatticeandcrystal,Translationalperiodicityandsymmetry,crystalsystems,spacelattice,representationofatomicposition,latticedirectionsandlatticeplanesincubicandhexagonalsystems;atomicpacking,voidsinFCC,BCCandHCPcrystals;crystalimperfections– point defect, line defect, surface defect and volume defect; equilibrium concentration of point defect. (12) Solidification of metals and alloys including Rapid Solidification Technology (6) Phase diagrams: The phase rule, single component system. Binary phase diagrams with reference to a few important metallic systems. (6) Corrosion and oxidation of materials: The principles of corrosion; Protection against corrosion; Mechanism of oxidation; Oxidation resistant materials. (6) Introduction to Materials (Classification, Selection and Applications): Metals and Alloys, Intermetallics, Polymers, Glasses and Ceramics, Composite Materials, nano-crystalline materials. (10)
Text Books,and/orreferencematerial	Text Books: 1. Materials Science and Engineering: A first course – V. Raghavan, PHI Learning Pvt.Ltd., 2004. 2. IntroductiontoMetallurgy-A.H.Cottrell,Arnold,1968. 3. Structure and Properties of Engineering Materials – R. M. Brick, A. W.Pense and R. B.Gordon. 4. The Structure and properties of Materials (I – IV) – R.M. Rose, L. A. Shepard and J.Wulff. 5. Introductiontosolids-L.V.Azaroff,TataMcGraw-Hill,1990. 6. Crystallographyappliedtosolid statephysics-A. R.Verma,O.N. Srivastava,Wiley,1982.

Department of Earh and Environmental Studeis							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC332	Economic Geology	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	• It helps to acquire technical knowledge of basic geological principles and their application in Metallurgical Engineering. • Enhances knowledge of natural resources and their utilization for Metallurgical purposes. • It enables to scientifically assess the materials of the earth and helps in solving industrial problems related to materials.

Topics Covered	Mineralogy: Definition, simple classifications, examples; Studies of crystals - symmetry elements, crystal classes and systems, twinning of crystals; Physical properties of minerals, Optical properties of minerals, Chemical characteristics, Atomic bonding in minerals, Structural classification of silicate minerals, occurrence. [10] Petrology: Igneous rocks - Magma – composition, physical properties; Rock cycle; Formation of Igneous rocks; Form and Structure; Classification; Texture; Phase diagram and crystallisation behaviour, Bowen's Reaction Series; Sedimentary rocks – Origin, classifications and examples, primary structures, textures; Metamorphic rocks – roles of agents of metamorphism, types of metamorphism, grades and degrees of metamorphism, metamorphic textures. [12] Structural Geology: Dip, Strike; Folds, Faults, Joints, Cleavage & Schistosity. [4] Economic Geology: Processes of formation of mineral deposits; Economic mineral deposits with special reference to Indian occurrences – Metallic minerals – Iron, Copper, Manganese, Aluminium, etc.; Non-metallic minerals – Refractory minerals, phosphate minerals. [10]
Text Books, and/or reference material	1) A Textbook of Geology : P. K. Mukherjee, World Press 2) The Principles of Petrology : G. W. Tyrrel; B. I. Publications 3) Dana's Manual of Mineralogy: Dana & ford 4) Economic Mineral Deposits: Jensen M. L & Bateman A. M

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	2	2	1	-	2	3	3	2	3
CO2	2	3	3	2	3	-	2	2	2	3	3	3
CO3	3	3	3	2	2	1	3	1	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC303	Non- Ferrous Process Metallurgy	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
CYC-01: Engineering Chemistry	CT+MT+EA
Course Outcomes	• CO1: Understand fundamentals and unit operations of Mineral Beneficiation (MB). • CO2: Understand developments in processing of non-ferrous metals. • CO3: Identify and solve the problems of industrial applications of MB unit.
Topics Covered	Sources of nonferrous metals (Sources in land and sea, exploration methods, methods of beneficiation, nonferrous metals wealth in India) (2)

	Principles of metals extraction, (Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, electro-chemistry) (8) General methods of extraction, (Pyro-metallurgy – calcinations, roasting (predominance area diagram) and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining)(6) General methods of refining, (Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk) (2) Extraction of metals from oxide sources, (Basic approaches and special features of specific extraction processes, extraction of metals such as Mg, Al, Sn) (5) Extraction of metals from sulphide ores, (Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc.) (5) Extraction of metals from halides, (Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as Ti, Ur) (5) Production of precious metals (Methods applied for gold, silver and Pt.) (3)
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Extraction of nonferrous metals, H.S. Ray, R.Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007). 2. H.S. Ray and A. Ghosh, Principles of extractive metallurgy,Wiley Eastern Ltd., New Delhi (1991) <u>Suggested Reference Books:</u> 1. W.H. Dennis, Extractive Metallurgy, Philosophical Library,New York (1965) 2. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York (1969). 3. T. Rosenqvist, Principles of Extractive Metallurgy, McGraw Hill, New York (1983). 4. J.L. Bray, Nonferrous production metallurgy, Wiley, NewYork(1954).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	1	1	1	3
CO2	3	3	2	2	1	1	2	1	1	1	1	3
CO3	3	3	3	3	2	1	2	1	3	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESS382	Economic Geology	PCR	0	0	3	3	1.5

	Laboratory						
Pre-requisites		Course Assessment methods (Continuous (CT) assessment)					
		CT					
Course Outcomes	● Students will develop concept of Symmetry of crystals of minerals used for metallurgical purposes. ● The students will learn to study the properties of minerals including ores under polarizing microscope which will contribute to the beneficiation process. ● Students will learn to solve geological problems associated with occurrence of new materials to be used for metallurgical purposes.						
Topics Covered	Experiment 1: To study the symmetry elements of crystals (Part 1). [3] Experiment 2: To study the symmetry elements of crystals (Part 2). [3] Experiment 3: To study the physical properties of minerals in hand specimens. [3] Experiment 4: Identification of minerals in hand specimens on the basis of physical properties. [3] Experiment 5: To study optical properties of minerals under Polarising Microscopes (Part 1). [3] Experiment 6: To study optical properties of minerals under Polarising Microscopes (Part 2). [3] Experiment 7: Determination of apparent dips in given directions from true dip. [3] Experiment 8: Determination of true dip from given apparent dips. [3] Experiment 9: Study of a geological map. [3]						

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS351	Metallurgical Thermodynamics and Kinetics Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) assessment)					
NIL		CT					
Course Outcomes	CO1: Learn to estimate the thermodynamic parameters from experiments CO2: Identify the rate law of a reaction and determine the rate constant CO3: Determine the value of activation energy for a reaction in a temperature range.						
Topics Covered	Experiment 1: Non-Isothermal Decomposition of pure Calcium Carbonate (3) Experiment 2: Non-Isothermal Decomposition of pure Magnesium Carbonate (3) Experiment 3: Oxidation kinetics of copper at elevated temperature (12) Experiment 4: Oxidation kinetics of mild steel at elevated temperature (12) Experiment 5: Determination of partial molar volume (3) Experiment 6: Determination of the stability of the oxide using Ellingham diagram. (3) Experiment 7: Study the reducibility of iron ore to evaluate$(dr/dt)_{40\%}$ (3)						
Text Books, and/or reference	Suggested Text Books: 4. Introduction to Metallurgical Thermodynamics – David R Gaskell. 2. Metallurgical 5. Textbook of Materials and Metallurgical Thermodynamics –A. Ghosh 6. Thermochemistry – O. Kubaschewski, E LL Evans and C B Alcock						

material	Suggested Reference Books: 4. Stoichometry and thermodynamics of Metallurgical processes - Y K Rao. 5. Problems in Metallurgical Thermodynamics and Kinetics – G S Upadhyay and R K Dube. 6. Chemical Kinetics - Keith Laidler.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1	1	1	1	1	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC401	Transport Phenomena in Metallurgical Processes	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT), and end assessment (EA))
XEC-01: Engineering Mechanics	CT+MT+EA

Course Outcomes	CO1: Understand the fundamentals of fluid flow and momentum transfer. CO2: Understand different modes of heat transfer and mass transfer. CO3: Ability to solve metallurgical industry oriented problems involving heat, mass, and momentum transfer.
Topics Covered	Introduction, Conservation, fluid statics. (3) Fluid flow: Newton's law of viscosity, Non-newtonian fluids. (5) continuity equation, Navier-Stokes equations, Laminar flow. (6) Turbulence and experimental correlations, the concept of friction factor. (3) Flow through porous media, fluidized bed, Ergun equation. EX: centrifugal casting, bottom gating system. (6) Modes of heat transfer, Industrial examples, Fundamental law and Subsidiary law (3) Concept of thermal resistance and overall heat transfer coefficient, Differential equation of heat conduction. (3) Conduction-convection system, Moving fins, Application in estimating heat losses from furnaces, Two dimensional steady state heat conduction. (3) Lumped heat capacity analysis, Time constant and response time of temperature measuring instruments, Heisler's charts, application in heat treatment and solidification. (4) Concept of the boundary layer, correlation for external flow and internal flow, continuous casting cooling system, heat losses from hot surfaces. (3) View factor between surfaces, radiation heat transfer in furnace enclosures, reactors in used in materials processing, radiation shields Case studies involving multimode heat transfer in materials processing. (5) Fick's Laws of diffusion, advection due to diffusion, case of evaporation of liquid through a column, Analogy between mass and heat transfer, mass transfer coefficient, application in gas-solid reactions such as oxidation, reduction etc. (7)
Text Books, and/or reference material	Suggested Text Books: 7. Rate Phenomena In process metallurgy – J. Szekely and N.J. Themelis 8. Transport Phenomena in Metallurgy – G.H. Geiger and D.R.Poirier Suggested Reference Books: 7. Heat Transfer– J.P. Holman 8. Heat and Mass Transfer – F. P. Incropera and D. P. DeWitt 9. Transport Phenomena – R. B. Bird, W. E. Stewart and E. N. Lightfoot

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1	1	1	1	1	1
CO3	3	3	3	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours: Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	Credit
MMC402	Phase Transformation and Phase Equilibria	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC302:Introduction to Metallurgy and Materials		CT+EA					
Course Outcomes	I. To understand and interpret Free energy-composition diagram and origin of phase diagrams. II. A detailed understanding on diffusion in solid and solid state phase transformations in steel. III. To understand the fundamentals of solidification in order to apply it in Foundry industry.						
Topics Covered	Introduction: Basic concepts about Stability of Phases and equilibrium; Types of PhaseTransformations,Orderoftransformations. (5 hours) Phase Equilibria: Thermodynamics of phase changes, phase diagrams and equilibria inrelationtoFreeenergy-compositiondiagrams.Interpretationofphasediagrams,determination and calculations. Solid-liquid Miscibility gap; invariant reaction. Principlesofternaryphasediagram,Examplesofafewmetallicandceramicphasediagrams.(6 hours) Diffusion:Phenomenologicalequationofdiffusion,Chemicalpotentialgradient,Fick'sfirst law of diffusion, diffusion coefficient (diffusivity), representation of diffusion flux interms of chemical potential gradient; Nernst-Einstein Equation, Diffusion in ideal solutionand in solutions with positive and negative deviation; Uphill diffusion, determination ofdiffusion coefficient (diffusivity) for ideal binary solid solution in terms of jump frequencyand jump distance, atomic mechanism of diffusion,Expression of diffusion coefficient(diffusivity) for self diffusion in pure metal or diffusion in substitutional solid solutionthrough vacancy mechanism and in interstitial solid solution; Steady state diffusion andtransientdiffusion;Fick'ssecondlawofdiffusion;determinationofselfdiffusioncoefficient by radioactive method; solution of Fick's second law: analysis of carburizinganddecarburizingprocesses;solutionofFick'ssecondlawforvariablediffusivity:Boltzmann-Matano analysis, Matano interface, determination of diffusivity as							

	a function ofconcentration;Diffusioninsubstitutionalsolidsolution:Kirkendalleffect,Darken'sanalysis. (10hours) Liquid-SolidPhaseTransformation:PrinciplesofSolidificationinmetalsandalloys:thermodynamicsinvolved,eutecticandperitecticSolidification,Homogeneousandheterogeneous nucleation,Mechanismsofgrowth.RapidSolidificationProcessing.(8 hours) Solid State Phase Transformations: Nucleation and growth Kinetics, homogeneous andheterogeneoustransformation,Precipitation:Coherency,agehardening,particleCoarsening.Ostwaldripening,Order-disordertransformation,spinodaldecomposition,massive transformations. (8hours) Solid State Phase Transformations in steel: Reconstructive and displacive transformations;Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology ofpearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite andlowerbainite;Martensitictransformation:Mechanism-diffusionlessdisplacivenature; morphologyofhigh carbonand lowcarbon martensite. (8hours)
Text Books, and/or reference material	Text Books: 1.Phasetransformationsinmetalsandalloys-D.A.PotterandK.E.Easterling,CRCPress, 1992. 2.TransformationsinMetals, P.G.Shewmon, Mc-GrawHill, 1969. 3. Introductionto PhysicalMetallurgy– S. N. Avner, TataMcGrawHill, 1997. 4.Physical Metallurgy–PeterHaasen,CambridgeUniversityPress, 1996. 5.PhysicalMetallurgyPrinciples,R.E.Reed-HillandR.Abbaschian,3rded,PWS-Kent Publishing,1992. 6.PhysicalMetallurgyforEngineers–A. G.Guy,Addison-WesleyPub.Co.,1962. 7.ModernPhysicalMetallurgy,R.E.Smallman,Butterworths,1963.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	1	-	3	-	-	3
CO2	3	3	3	3	2	-	2	-	2	1	2	2
CO3	3	3	3	-	3	3	3	2	3	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC403	Materials Characterization	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT)					

	and end assessment (EA))
MMC-302: Introduction to Metallurgy and Materials	CT+MT+EA
Course Outcomes	I. Learn fundamentals of X-ray diffraction, electron microscopy and other characterization techniques. II. Identify the crystal structure and index the diffraction patterns of different phases to meet contemporary needs (including tutorials). III. Learn different applications and developments in characterization techniques.
Topics Covered	**X-ray basics:** Production of X-ray; The continuous and characteristic spectrum; Absorption; Filters. 4h **Elementary Crystallography:** Overview the basics of crystallography; real and reciprocal lattice. 2h **X-ray diffraction:** Bragg's Law; Ewald sphere construction; Diffraction methods– Laue method, rotating crystal methods, powder methods; Diffractometers; diffraction under non ideal condition; 6h **Intensity of diffracted beams:** Structure factor calculations and other factors; Extinction rules; 4h **Application of X-ray diffraction:** Crystal structure determination; Precise lattice parameter measurements; Phase diagram determination, Chemical analysis by diffraction, residual stress determination, particle size determination. 10h **Electron microscopy:** elements of transmission electron microscopy; Sample preparation techniques for TEM, Image contrast in TEM: Identification of crystal defects and precipitates. Diffraction pattern analysis. 12h Advanced Materials Characterization: Thermal characterization of materials; Precipitation kinetics, Characterization through atomic force microscope. 6h
Text Books, and/or reference material	Text Books: 1. "Elements of X-Ray Diffraction", by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968. 2. "X-ray diffraction-a practical approach", by C. Suryanarayana and M. Grant Norton, Springer, 1998. 3. "X-ray Diffraction: Its Theory and Applications", by S. K. Chatterjee, Prentice-Hall of India Pvt. Limited,2004. *4. "Electron Microscopy in the Study of Materials"*, by *P.J. Grundy and G.A. Jones*, Arnold, London, 1976. 5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. **Williams** and C. Barry **Carter**, 2nd ed., Springer, 2009. 6. "Electron Microscopy and Analysis", by Peter J. Goodhew, John Humphreys and Richard Beanland, Third Edition, CRC Press, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	1		1	2	3		3	1	1	1	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC433	Data Structures	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))
Introduction to computing which covers the following preliminary concepts: (a) Number Systems, different parts of a computer system, flowchart, Algorithm, (b) Time and Space Complexities of algorithm, high level programming (c) Language-C, etc.	CE+EA

Course Outcomes	1. Student will be able to choose appropriate data structure as applied to specified problem definition. 2. Student will be able to handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures. 3. Students will be able to implement the concepts learned in various domains like DBMS, compiler construction etc. 4. Students will be able to decide the applicability of the concepts of stacks, queues, linked list etc. in different types of applications.
Topics Covered	• Introduction: Algorithms versus Programming, Definition of Data Structures, Characteristics of algorithms, Abstract data types, Asymptotic notations, Computation of time complexity, Static and dynamic memory allocations. [6] • Arrays: Single and multi-dimensional arrays, Row and column major representation of matrices, sparse matrices [4] • Linked Lists: Linked list as ADT, Singly, doubly, and circular linked lists. Different operations on singly and doubly linked lists: insertion, deletion, searching and modification of a node. Array representation of linked lists. Applications: Operations on polynomials. [6] • Stacks: Stack as an ADT, Stack representations with array and linked lists, Operations on stacks: push AND pop, Applications of stacks: subroutine call, recursive function call, conversion of infix to postfix expressions, evaluation of postfix expression using stack, checking validity of a parenthesized expression. [5] • Queues: Queue as an ADT, Queue representations with array and linked lists, Queue operations: addqueue and dequeue, circular queue and its operations, concept of priority queues. [5] • Trees: Basic terminology, Binary tree and its implementation, Tree traversal techniques, threaded binary tree, Binary search tree and its operations. [6] • Searching: Sequential search, binary search.

	[2] • Sorting: Definition of sorting, internal and external sorts, Insertion Sort, Bubble Sort, Selection sort, Quick Sort, Merge Sort, Heap sort. [8]
Text Books, and/or reference material	Text Books: • Data Structures: A Pseudo code Approach with C, Richard F. Gilberg & Behrouz A. Forouzan, second edition, CENGAGE Learning. • Data Structures using C, Reema Thareja, Oxford University press. • Data Structure using C & C++, Angenstein & Tanenbaum, PHI. • An introduction to Data Structure, Trembly & Sorensen, MCHILL. • Data Structure & Algorithms, Aho, Hopcroft & Ullman, AddnWesley.

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS483	Data Structures Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Knowledge of programming		CE+EA					
Course Outcomes	CO1: Student will be able to implement basic applications using data structures as applied to specified problem definition. CO2: Student will be able to handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures. CO3: Students will be able to implement the concepts learned in various domains. CO4: Students will be able to decide the applicability of the concepts of stacks, queues, linked list etc. in different types of applications.						
Topics Covered	• Arrays: Implementation of insertion, deletion, merging and sparse matrix using arrays. • Linked lists: (a) Implementation of insertion, deletion, searching and merge with singly and doubly connected linked lists. (b) Implementation of polynomial addition using linked list. • Stacks: (a) Implementation of PUSH and POP operations using array and linked lists. (b) Implementation of conversion of infix to postfix expressions, evaluation of postfix expression using stack and checking validity of a parenthesized expression. • Queues: (a) Implementation of Enqueue and Dequeue operations using array and linked lists. (b) Implementation of circular queue. • Trees: (a) Implementation of tree traversal techniques. (b) Implementation of insertion, deletion and searching a node on a binary search tree. • Searching: Implementation of sequential and binary search. • Sorting: Implementation of Insertion Sort, Bubble Sort, Selection sort, Quick Sort, Merge Sort and Heap sort.						
Text Books, and/or reference	Text Books: • Data Structures: A Pseudo code Approach with C, Richard F. Gilberg & Behrouz A. Forouzan, second edition, CENGAGE Learning.						

material	• Data Structures using C, Reema Thareja, Oxford University press. • Data Structure using C & C++, Angenstein & Tanenbaum, PHI. • An introduction to Data Structure, Trembly & Sorensen, MCHILL. • Data Structure & Algorithms, Aho, Hopcroft & Ullman, AddnWesley.

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS451	Transport Phenomena Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) assessment)					
NIL		CT					

Course Outcomes	CO1: Identify the nature of Flow. CO2: Determine the value of the different constants in a fluid flow and heat transfer. CO3: Evaluate the thermal conductivity and diffusivity for a particular system.
Topics Covered	Experiment 1: Measurement of Reynold's Number Experiment 2: Measurement of friction factor during fluid flow in a pipe Experiment 3: Measurement of total energy across various points in a fluid flow system Experiment 4: Measurement of coefficient discharge through a venturimeter. Experiment 5: Measurement of coefficient discharge through an orificemeter. Experiment 6: Measurement of pressure drop through a packed bed Experiment 7: Measurement of coefficient of Pitot Tube and point velocity at different points across the flow Experiment 8: Determination of Stefan – Boltzman Constant Experiment 9: Measurement of thermal Conductivity of Metal Rod Experiment 10: Study the molecular diffusion of vapors in air
Text Books, and/or reference material	Suggested Text Books: 1. Fundamentals of Momentum, Heat, and Mass Transfer by Welty, Wicks, Wilson, and Rorrer 2. Transport Phenomena – R. Byron Bird, Warren E. Stewart, Edwin N. Suggested Reference Books: 1. An Introduction to Transport Phenomena in Materials Engineering – D. R. Gaskell, 2. A Textbook on Heat Transfer –S. P. Sukhatme

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	2	3	3	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core(PCR) / Electives(PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMS452</td><td>Phase Transformation and Phase Equilibria Lab</td><td>PCR</td><td>0</td><td>0</td><td>6</td><td>6</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. To introspect phase equilibria and phase transformation in steels of varying carbon content through investigation of microstructure in correlation to iron-carbon diagram.
II. To investigate microstructures of different cast irons in correlation to associated phase equilibria and phase transformation.
III. To understandtheapplication ofleverrule andphaserule.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">(i) Experiment1:Investigationsofthe microstructuresof pure metals(Fe,Cu,Zn,Al)
(ii)Investigationofthemicrostructuresofcarbonsteelscontaining~0.2%C,~0.4%C, ~0.6%C,~0.8%C,~1.0%C,incorrelationwithphaseequilibriainFe-Csystem(Iron–Carbonphasediagram).
Experiment2(PartI):Microstructureof0.2wt.%C steel (4hours)
Experiment3(PartII):Microstructure of 0.4wt.%Csteel (4hours)
Experiment4 (PartIII): Microstructure of0.6wt.% Csteel (4hours)
Experiment5(PartIV):Microstructure of0.8wt.% Csteel (4hours)
Experiment6 (PartV):Microstructureof1.0 wt.% Csteel (4hours)
(iii) With regard to Fe-C-Si phase equilibria, investigation of the microstructure of differenttypes of cast irons, viz. White Cast iron, Grey Cast iron, Spheroidal (Nodular) graphite castironandMalleablecast iron.
Experiment8 (PartI): MicrostructureofWhite Castiron (4hours)
Experiment9(PartII):Microstructure ofGreyCastiron (4 hours)Experiment10(PartIII):MicrostructureofSpheroidal(Nodular)graphitecastiron (4hours)
Experiment11(PartIV):Microstructure ofMalleable castiron (4hours)
(iv) Experiment 12: Study of the precipitation hardening process in Duralumin (Al-4.5%Cualloy) (3 hours)
(v) Experiment 13: ApplicationofLeverRule. (3 hours)
(vi)Experiment14:ApplicationofPhaseRuletodifferenttypesofbinaryphasediagrams.(3 hours)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Textbook:
1. Phasetransformationsinmetalsandalloys-D.A. Potter andK.E. Easterling,CRCPress, 1992.2. Introductionto PhysicalMetallurgy– S. N. Avner,Tata McGrawHill, 1997.
3.PhysicalMetallurgyPrinciples, R.E.Reed-HillandR.Abbaschian,3rded,PWS-Kent Publishing,1992.
4.ModernPhysicalMetallurgy,R.E.Smallman,Butterworths,1963.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	3	2	2	1	3	2	2	2
CO2	3	2	1	-	3	2	2	1	3	2	2	2
CO3	3	3	3	1	1	-	-	-	3	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO441	Brain to Mind Creation	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01: Life Science		CT+MT+EA					
Course Outcomes	• CO1: Understanding Cognitive Science and the Processes • CO2: Understanding the Physics and Electrochemical Reactions in Brain. • CO3 : Understanding the Behavioral Pattern of a Human Being						
Topics Covered	Brain to Mind-- and how do we know it---(essentially single neuron to multiple). (4) Brain and gross specialization --- areas , right-left , association ,connectivity and our tools to learn including EEG (6) Being Conscious -- Dynamics --- how do we learn about it from EEG (8) Cognition, Memory, Emotion -- Normal and Pathology . (6) Sleep and neural network (4) Brain and Future-- with interactive session (2)						
Text Books, and/or reference material	Suggested Text Books: 1) Biological basis of Behavior- Prof. Braj Bhushan 2) A Beautiful Mind - Dr. Alok Bajpai 3) Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience, 2nd Edition by Bernard J. Baars (Author), Suggested Reference Books: Principles of Neural Science, Fifth Edition by Eric R. Kandel and James H. Schwartz						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC501	Manufacturing Processes	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MMC-301: Metallurgical Thermodynamics and Kinetics	CT+EA

Course Outcomes	• To understand different Manufacturing Processes • Ability to design casting techniques and the basics of Welding Metallurgy • To have ability to have a practical concept of manufacturing objects.
Topics Covered	Introduction to casting as a shaping technique; Characteristic and effects of sand, binders and additives; Different types of Moulding and Machine moulding; Special casting techniques (12) Design of Gating and Risering of casting; Solidification (5) Melting furnace- cupola, rotary furnace, induction furnace; Defects in casting and their remedy; Metallurgy of cast iron, Aluminium and copper based alloy. (12) Joining: Physics of welding, Process of different welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints. (14) Historical perspective of Powder Metallurgy; Reasons for using Powder Metallurgy; The Future of Powder Metallurgy; Powder Fabrication: Different powder fabrication techniques; Powder Characterization: Experimental methods for measuring particle size, shape, distribution, surface area; Significance of true, apparent and tap densities of powders; Flow rate of powders and its significance; compressibility and green strength; Powder Handling: Powder Packing; Mixing and Blending; Mixing with Binders and Lubricants; Powder Lubrication; Compaction: Phenomenology of Powder Compaction; Conventional Compaction; Fundamentals of Compaction; Influence of Material and Powder Characteristics; Sintering: Sintering fundamentals; Full Density Processing. (14)
Text Books, and/or reference material	Text Books: 1. O. P. Khanna: Foundry technology, 17th Edition, DhanpatRai Publications, 2011. 2. Rajender Singh: Introduction to Basic Manufacturing Processes & Workshop Technology, New Age International (P) Limited, Publishers, 2006. 3. R. A. Flinn: Fundamentals of Metal Casting, Addison-Wesley; Underlining edition, 4. Powder Metallurgy – AUpadhyaya and G S Upadhyaya. 5. Powder metallurgy: principles and applications- Fritz V. Lenel Reference Books: 1. P. L. Jain: Principles of Foundry Technology, 5th Edition, Tata Mcgraw Hill Education Private, 2009.

	2. M. C. Flemings: Solidification processing, McGraw-Hill, 1974. 3. Metals Handbook, Casting, vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998.

MMC 501 **Mapping of CO (Course Outcome) and PO (Programme Outcome)**

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	1	2	3	1	1	3	1
CO2	1	1	2	1	3	2	2	3	2	2	2	1
CO3	1	2	1	1	3	2	2	3	1	1	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC 502	Heat Treatment of Materials	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Phase Transformation and Phase Equilibria (MMC 402)		CT+MT+EA					
Course Outcomes	• CO1: To learn the theory of heat treatment including the kinetic principles of solid state transformations. • CO2: To understanding of the role of heat treatment on the development of microstructure and properties of metallic materials. • CO3: The course will highlight a number of commercially-significant applications where heat treatment are important.						
Topics Covered	Objectives and Principles of heat treatment. [1 hour] Iron-Carbon Phase Equilibrium Diagram; Austenitisation, Transformation of austenite to pearlite, bainite and martensite; Characteristics of transformation products. [6 hours] T-T-T-and C-C-T diagrams; Factors affecting T-T-T curves. [6 hours] Heat treatment processes: Different types of annealing, spheroidizing, normalsing, hardening, tempering, patenting, austempering, martempering, Sub-zero treatment. [8 hours] Thermo mechanical treatment of Steels; Ausforming, Isoforming, Cryoforming, Heat removal mechanism, Hardenability of steels– Significance of hardenability, Determination of hardenability, Jominy End quench test, Factors influencing hardenability. [6 hours] Heat Treatment Defects, Residual stresses developed upon heat treatment [2 hours] Age Hardening: Basic requirements and steps, [1 hour] Heat treatment of non-ferrous metal and alloys -Aluminium alloys, Copper alloys, Magnesium alloys, Titanium alloys.							

	[6 hours] Practical considerations in heat treatment: Accessories, Cooling media, Types of furnace and Furnace atmosphere. [1 hour] Surface heat treatment – Carburizing of steels, Cyniding and Carbonitriding, Nitriding, Flame hardening, Induction hardening, Laser hardening etc. [6 hours]
Text Books, and/or reference material	**Suggested Text Books:** An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company. ASM Metals Hand Book – Vol. IX, ASM International Materials Society. Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, Charlie R. Brooks, ASM international, 1996. **Suggested Reference Books:** Principles of Heat Treatment – R. C. Sharma, New Age International (P) Ltd. Heat Treatment of Metals – V. Singh (Standard Publication Distributors) New Delhi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1							2	3	3
CO2	3	3	3							2	3	3
CO3	3	3	3							3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC503	Fundamentals of Plastic Deformation & Strengthening of Materials	PCR	3	1	0	4	4
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
Nil			CT+EA				
Course Outcomes	CO1: To understand the fundamental concepts of plastic deformation of materials CO2: To know about various lattice defects and the roles played by these defects in plastic deformation and strengthening of materials CO3: To correlate the fundamentals ideas of deformation and strengthening with the observations in materials testing and mechanical processing						

Topics Covered	**Introduction and various types of plastic deformation:** Concept of stresses and strains, engineering stress and strain, true stress and strain, different types of loading for bulk deformation, slow strain rate deformation, evaluation of mechanical properties of materials by tensile and compression testing, stress-strain response of different materials - elastic region, yield point, plastic deformation, necking and fracture, effects of strain rate and temperature on stress-strain response of materials, superplastic behavior, evaluation of shear stress - shear strain curve from torsion testing, deformation and fracture of materials under impact loading, ductile to brittle transition, elementary concept of fatigue deformation and fracture, elementary concept of creep deformation and fracture, localized deformation at surface and indentation hardness, different methods of hardness measurement. [26 h] **Mechanisms of plastic deformation and strengthening:** Plastic deformation by slip, slip system, slip line, slip band, critical resolved shear stress (CRSS) of a material, theoretical shear strength, defects/imperfections in crystals, classification of defects, thermodynamics of defects, geometry of dislocations, Burgers vector, Burgers circuit, various types of dislocations, dislocation glide, Peierls stress, partial dislocations and stacking faults, cross slip, dislocation climb, intersection of dislocations, jogs and kinks in dislocation, force on a dislocation, line tension of a dislocation, dislocation generation - Frank-Read and grain boundary sources, stress and strain field around dislocations, strain energy of a dislocation, dislocation interactions, forces between dislocations, polygonization, dislocation movement and strain rate, deformation behavior of single crystals - flow curve and strain hardening/work hardening mechanisms of single crystals, deformation behavior of polycrystalline aggregates, plastic deformation by twinning, interaction between dislocations and interstitial atoms - yield point phenomena and strain ageing, dislocation phenomena involved in fatigue and fracture, Hall-Petch and other hardening mechanisms of polycrystalline aggregates, grain size effect, Hall-Petch breakdown, strengthening due to fine particles, fiber strengthening, solid solution strengthening, strengthening due to point defects, plastic deformation of two-phase aggregates, cold-worked structure of polycrystalline materials, annealing of cold-worked polycrystalline materials, Bauschinger effect, preferred orientation.[30 h]
Text Books, and/or reference material	• Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill (UK) Limited, 1988 • Mechanical Behavior of Materials, *William F. Hosford,* Cambridge University Press, New York, 2005 • Mechanical Behavior of Materials, Second Edition, *Marc A. Meyers and Krishan K. Chawla,* Cambridge University Press, New York, 2009 • Mechanical Behavior of Materials, 2nd Ed., *Thomas H. Courtney,* Waveland Press, Inc., Illinois, 2005 • The Plastic Deformation of Metals, *R.W.K. Honeycombe,* Edward Arnold, 1968 • Dislocations and Plastic Flow in Crystals, *A.H. Cottrell,* Clarendon Press, 1965

CO-PO Mapping

POs COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	3	2	2	2			1			
2	3	2	3	3	3	1			1			
3	3	2	3	2	3	1			1			2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC504</td><td>Iron Making</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MMC-301: Metallurgical Thermodynamics and Kinetics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand fundamentals of physico-chemical principles of blast furnace iron making.
• CO2: Understand the design & operational aspects of blast furnace technology.
• CO3: Understand the development in alternative iron making processes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">History of Iron Making Pig Iron production in India. (2)
Raw Materials – Valuation and preparation of raw materials (6)
Methods of Agglomeration: sintering, pelletizing. (6)
Testing of raw materials. (2)
Design and construction of the blast furnace. (2)
Theory and practice of pig iron making – charge distribution, burden calculation. mass balance (4)
Physico-chemical aspects of blast furnace reactions, Blast furnace slags. Operating line (6)
Developments in blast furnace practice. Blast furnace irregularities. (4)
Blast furnace accessories: blowers, stoves, gas cleaning plants. (4)
Alternative methods of Iron making. (4)
Manufacture of ferro alloys. (2)
Environmental considerations in iron making. (1)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. A Text Book on Modern Iron Making - R. H. Tupkary (new edition)
2. Principles of Iron Making - A. K. Biswas.
3. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008
<u>Suggested Reference Books:</u>
1. Manufacture of Iron & Steel. Vol. I.- G. B. Bashforth.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	1	1	1	1	1	1	1	2
CO2	3	3	2	3	1	1	2	1	3	3	1	2
CO3	3	3	3	3	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS551	Manufacturing Processes Lab - I	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	• To understand the basic of metal Casting and the techniques of welding. • To understand casting and welding defects and methods of elimination. • To understand the microstructures of three different zones of a welded portion.						
Topics Covered	Experiment-1: Determination of various properties of sand -clay -water mixture Experiment-2 : Design and preparation of green sand mould with various gating system Experiment-3 : Melting and Casting of Aluminum in green sand mould Experiment-4 : Welding of Butt -Joint by MMAW Experiment-5 : Determination of various defects by NDT of weld Joint Experiment-6 : Observation of Microstructure of welded joint Experiment-7 : Welding of Butt -Joint by TIG Experiment -8 : Comparison weld by 2 different Routes.						
Text Books, and/or reference material	Text Books: 1. O. P. Khanna: Foundry technology, 17th Edition, Dhanpat Rai Publications,2011 2. P. L. Jain: Principles of Foundry Technology, 5th Edition, Tata Mcgraw Hill Education Private, 2009.						

MMS 551 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	1	2	3	1	1	3	1
CO2	1	1	2	1	3	2	3	3	2	2	2	2
CO3	1	2	1	1	3	2	2	3	1	3	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS 552	Heat treatment of Materials	PCR	0	0	3	3	2

	Laboratory						

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Phase Transformation and Phase Equilibria (MMC 402)	CT+MT+EA
Course Outcomes	CO1: To learn fundamental of change in microstructure, hardness and mechanical properties with different cooling rate, cooling medium and temperature CO2: To understand the change in surface structure and property with chemical treatment CO3: To get an overall idea on a microstructure and assessment of hardness and mechanical property of steel under various industrial cooling condition.
Topics Covered	Acquaintance with Furnaces and their Operation [3 hours] Annealing, normalizing, hardening, and tempering treatments of plain carbon steels [12 hours] Influence of underheating and overheating on microstructure and properties [3 hours] Jominy End Quench Test [3 hours] Determination of critical diameter of Steel by trial hardening method. [6 hours] Pack Carburizing of steels, Post-carburizing heat treatment, Measurement of case depth. [6 hours
Text Books, and/or reference material	Suggested Text Books: 1. Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, Charlie R. Brooks, ASM international, 1996. 2. ASM Metals Hand Book – Vol. IX, ASM International Materials Society. Suggested Reference Books: 1. Principles of Heat Treatment – R. C. Sharma, New Age International (P) Ltd. 2. Heat Treatment of Metals – V. Singh (Standard Publication Distributors) New Delhi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1								3	3
CO2	3	3	1	1							3	3
CO3	3	3	1	2							3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS553	Plastic Deformation & Strengthening of Materials Lab	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Nil	EA

Course Outcomes	CO1: To know about the method of tension, compression, torsion, impact, hardness testing CO2: To analyze the results of different mechanical testing and interpret the mechanical behaviour of the materials CO3: To correlate structure with the mechanical properties under different conditions of deformation
Topics Covered	1) Tensile and compression testing of ductile (metallic) materials and evaluation of strength and ductility properties [6 h] 2) Evaluation of shear stress - shear strain plot of ductile metals and alloys from torsion testing and determination of useful mechanical properties [6] 3) Studying localized deformation at surface of metallic materials by various hardness testing methods [3] 4) Studying materials behavior under impact loading by Charpy V-notch testing [3] 5) Studying the effects of cold working and annealing on the hardness and microstructure of ductile metals and alloys [18]
Text Books, and/or reference material	• Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill Book Company (UK) Limited, 1988 • Mechanical Behavior of Materials, *William F. Hosford,* Cambridge University Press, New York, 2005 • Mechanical Behavior of Materials, Second Edition, *Marc A. Meyers and Krishan K. Chawla,* Cambridge University Press, New York, 2009

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MMS553	CO1	3	3	2	2	2	2	1	1	1	-	1	1
	CO2	3	3	1	1	2	3	1	1	1	-	-	-
	CO3	3	2	1	3	3	2	1	1	1	1	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	Economics and Management Accountancy	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes

- Learners will be able to review basic economic principles.
- Learners will be introduced to the basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works.
- Learners will gain a good knowledge of financial accounting, enabling them prepare, analyse and interpret financial statements for taking informed decisions.

Topics Covered

PART 1: Economics

Group A: Microeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Economics: Basic Concepts	2	0	0	2	2
Unit 2:	Theory of Consumer Behaviour	3	0	0	3	3
Unit 3:	Theory of Production, Cost and Firms	3	0	0	3	3
Unit 4:	Analyses of Market Structures: Perfect Competition	3	0	0	3	3
Unit 5:	Monopoly Market	2	0	0	2	2
Unit 6:	General Equilibrium & Welfare Economics	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Macroeconomic Theory	2	0	0	2	2
Unit 2:	National Income Accounting	3	0	0	3	3
Unit 3:	Determination of Equilibrium Level of Income	4	0	0	4	4
Unit 4:	Money, Interest and Income	2	0	0	2	2
Unit 5:	Inflation and Unemployment	2	0	0	2	2
Unit 6:	Output, Price and Employment	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

Group B: Macroeconomics

PART 2: Management Accountancy

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	**Introduction to Accounting**: Accounting Environment of Business; Objectives of Accounting; Accounting Equations for Financial Statements. Books of Accounting: Journal, Ledger, Cash book.	3	0	0	3	3

	Unit 2:	**Financial Statement Preparation and Analysis:** Preparation of Trial Balance, Trading, Profit & Loss account and Balance Sheet. Case study discussion.	5	0	0	5	5
	Unit 3:	**Financial Ratio Analysis:** Common Size Statements; Computation of Financial Ratios; Interpretation and analysis of Financial Ratios with the help of case studies.	4	0	0	4	4
		TOTAL	**12**	**0**	**0**	**12**	**12**
Text Books, and/or reference material		**PART 1: Economics** **Group A: Microeconomics** 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics **Group B: Microeconomics** 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. Soumyen Sikder: Principles of Macroeconomics **PART 2: Management Accountancy** 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.					

CO-PO MAPPING of Economics and Management Accountancy (HSC631)

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	-	-	-	1	-	-	-	-	-	2	3	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC601	Steel Making	PCR	3	1	0	4	4
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
MMC-301: Metallurgical Thermodynamics and Kinetics			CT+MT+EA				
Course Outcomes	• CO1: Understand fundamentals of physicochemical principles of steel making • CO2: Understand the design & operational aspects of steel making						

	technology. • CO3 :Understand the design & operational aspects of Continuous Casting
Topics Covered	Historical Perspective, An Overview of Modern Steel making. (2) Steelmaking Fundamentals - Chemical Reactions Equilibria, Steel Making Slag (6) LD Steelmaking process - Design aspects of Converter and Lance ; LD Shop Layout, Charge Calculations ;Raw Materials ; Blowing Curve and theories of LD Steelmaking. (6) Bottom Blown Steelmaking - Distinctive Features and combined blow (4) Steelmaking in Electric Arc Furnaces (EAF) - Construction of an Arc Furnace ; Operation ; Developments in EAF steelmaking Technology. Alloy Steelmaking and stainless steel making 6) Refractory in steelmaking - Requirements and various types of refractory Material (2) Secondary Steelmaking: Types of Deoxidation and Deoxidation Kinetics and Products. Vacuum Degassing - Principles - Degassing Techniques (4) Ladle Metallurgy : V.A.D ; V.O.D ; R H (4) Ingot Casting and its Defects (2) Continuous Casting - Process description - Continuous Casting Products (5) Near net shape Casting (1)
Text Books, and/or reference material	Suggested Text Books: 1. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008. 2. Steel Making - By R.H. Tupkary 3. Steel Making - By A Chakroborty. Suggested Reference Books: 1. Turkdogan, E.T., A Text Book of Steelmaking, Academic Press, London, 1997. 2. Ghosh, A., Secondary Steelmaking, CRC Press, Boca Raton, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	3	1	1	3
CO2	3	3	3	3	1	1	1	1	2	1	1	3
CO3	3	3	3	3	2	1	1	1	3	1	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC602	Mechanical Working of Materials	PCR	3	0	0	3	3

<table>
<tr><td colspan="2">Pre-requisites</td><td>Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC503: Fundamentals of Plastic Deformation & Strengthening of Materials</td><td>CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">CO1: To understand the mechanics of metal forming processes
CO2: To know about tools and techniques of different metal forming processes
CO3: To understand the parameters which are needed to be controlled for increasing quality and productivity of different metal forming operations</td></tr>
<tr><td>Topics Covered</td><td colspan="2">1) Introduction: Overview, objectives of mechanical working or plastic deformation of materials, classification of plastic deformation processes, mechanics of mechanical working of materials, influence of friction and lubrication in mechanical working processes, workability. [6h]
2) Theory of Elasticity: Description of stress and strain at a point within a loaded body, stress tensor, principal stresses under 3D state of stress, concept of Mohr's circle construction and its implications under 3D state of stress, hydrostatic and deviator components of stress, elastic stress - strain relations, strain energy. [10h]
3) Theory of Plasticity: Yielding criteria for ductile metals, yield locus, yield surface, plastic stress - strain relations, plane strain condition of plastic deformation, stress analysis under plane strain condition of plastic deformation using slip line - field theory. [10h]
4) Rolling: Classification of rolling processes, forces and geometrical relationships in rolling, angle of bite, neutral point, theories of cold rolling and hot rolling, calculation of rolling load, torque and horse power, maximum allowable back tension in cold rolling, variables controlling rolling process, common defects in rolled products and their remedies. [8h]
5) Forging: Classification of forging processes, open-die forging, closed-die forging, stress distribution in open-die forging, calculation of forging load, common forging defects. [6h]
6) Extrusion: Classification of extrusion processes, analysis of extrusion process, hot extrusion, cold extrusion, deformation, lubrication and defects in extrusion processes, hydrostatic extrusion, extrusion for producing tubes. [5h]
7) Drawing: Different types of drawing processes, analysis of wire drawing and tube drawing, limit of drawability, residual stresses in drawn products. [3h]
8) Sheet - Metal Forming: Various sheet-metal forming processes, stretch forming, deep drawing, limiting draw ratio, forming limit criteria, defects in sheet-formed products. [8h]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="2">• Mechanical Metallurgy, SI Metric Edition, George E. Dieter, McGraw-Hill Book Company, London, 1988
• Principles of Industrial Metal Working Processes, G.W. Rowe, CBS Publishers & Distributors, New Delhi, 2005
• Metal Forming: Mechanics and Metallurgy, 3rd Edition, William F. Hosford and Robert M. Caddell, Cambridge University Press, New York, 2007
• The Rolling of Strip, Sheet and Plate, 2nd Edition, E.C. Larke, Chapman and Hall, Ltd., London, 1963</td></tr>
</table>

	• The Extrusion of Metals, 2nd Edition, *C.E. Pearson and R.N. Parkins,* John Wiley & Sons, Inc., New York, 1960 • Wire Technology, 1st Edition, *Roger Wright,* Butterworth-Heinemann, 2010 • Metal Forming: Processes and Analysis, *B. Avitzur,* McGraw-Hill Book Company, New York, 1968 • Mechanical Working of Metals: Theory and Practice, *J.N. Harris,* Pergamon Press, 1983 • Principles of Metal Working, *Surender Kumar,* Oxford & IBH Publishing Company, 1985 • An Introduction to Plasticity, *G.C. Spencer,* Chapman & Hall, London, 1968

CO-PO Mapping

POs COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	1	3	3		1		2	1		1
2	3	2	3	3	3	1	1		3	2		2
3	2	3	1	3	2	2	1		3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME 610	Engineering Materials	PCL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Introduction to Metallurgy and Materials (MMC 302)		CT+MT+EA					
Course Outcomes	• CO1: To learn the basic fundamental of internal structure and properties of different metals • CO2: To understand the microstructure-property relationship for various engineering applications in different conditions • CO3: To learn technology aspect on application of engineering materials						
Topics Covered	Introduction to Various Classes of Engineering Materials: Factors affecting selection of Engineering Materials-Service requirements, fabrication requirements and economic requirements. [2 hours] Study of the industrially important of steels, their mechanical and thermal treatment and uses: Plain carbon steels. Conventional low carbon steels. [5 hours] Mild Steel, Dual Phase Steels and High Strength Low alloys (HSLA) Steels. [4 hours] Effect of Alloying Elements in Steel. [2 hours] Alloy Steels: Manganese Steels, Hadfield manganese Steel, [2 hours]						

	Heat Resistant and Stainless Steels. [8 hours] Tool and Die Steels, High speed tool steel (HSTS), Maraging Steels. [4 hours] Study of Nonferrous Alloys, their mechanical and thermal treatment: Brasses, Bronzes, Bearing Metals, Light alloys based on Aluminium and Magneium, Titanium Base alloys [10 hours] Alloy cast irons, Special purpose materials, such as, Cryogenic and High temperature Materials, Materials for Aerospace, Nuclear Reactors etc. [4 hours] Electrical and Magnetic Materials. [2 hours]
Text Books, and/or reference material	Suggested Text Books: 1. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company. 2. Structure and properties of materials – J Wulff and other. Vols. I–IV. Wiley Eastern pub Ltd. New Delhi 3. Metallurgy for Engineers – E C Rollason 4. Physical Metallurgy – Vijendra Singh. 5. Engineering Materials : H. J. Sharp Haywood, London (1961) 6. Engineering Materials : M. F. Ashby and D. R. N. jones, Pergamon press Oxford (1980). Suggested Reference Books: 7. Materials Science and Engineering by Raghavan - PHI 8. Physical Metallurgy of Engineering Materials, N. R. petty, Allen Unwin (1968) 9. Light Alloys: Metallurgy of the light Metals, I.J. Polmser-Edwaraed annord. 10. The Super alloys by C. T. Sims and W. C. Hegel –Wily-Interscience.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3								2	2
CO2	3	3	2								2	3
CO3	3	3	3								3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME611	Electronic and Thermal Properties of Materials	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC302: Introduction to		CT+EA					

Metallurgy and Materials	
Course Outcomes	CO1: To get fundamental understanding about the quantum mechanics theory related with the electronic structure of solid state materials CO2: To know about fundamentals of electron transport and electrical conductivity of conducting, semiconducting and insulating materials CO3: To know about fundamentals of conductive heat transfer and thermal conductivity of solid materials
Topics Covered	1. **Introduction:** Overview; wave - particle duality. [4 h] 2. **Fundamentals of Electron Theory:** Schrodinger equation; solution of Schrodinger equation; energy bands in crystals; Brillouin zones; free electron bands; band structure of metals and semiconductors; electrons in crystals; Fermi energy; Fermi distribution function; density of states. [18 h] 3. **Electrical Properties of Materials:** Electrical conduction - classical electron theory, quantum mechanical consideration; superconductivity; thermoelectric phenomena; galvano-electric phenomena; semiconductor - intrinsic and extrinsic; band structure; Hall effect; semiconductor devices; electrical properties of polymers, ceramics, dielectrics, and amorphous materials. [18 h] 4. **Thermal Properties of Materials:** Heat capacity; thermal conductivity; classical and quantum mechanical consideration for heat capacity and thermal conductivity; phonon spectrum; thermal expansion. [6 h]
Text Books, and/or reference material	• Electronic Properties of Materials, *Rolf E.* ***Hummel,*** Springer-Verlag, New York, 2011 • Electronic Properties of Engineering Materials, *James D. Livingston,* John Wiley & Sons, 1999 • Electronic, Magnetic, and Thermal Properties of Solid Materials, *Klaus Schroder,* Marcel Dekker Inc, 1978 • Thermophysical Properties of Materials, *Göran Grimvall, Elsevier, B.V., 1999*

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	-	-	1	1	-	3
CO2	3	3	3	2	1	-	-	-	1	1	-	3
CO3	3	3	3	2	1	-	-	-	1	1	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME612	Alternative Routes of Iron Making	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					

MMC-504: Iron Making, MMC-301:Thermodynamics & Kineticsof Engineering Materials		CT+EA
Course Outcomes	• CO1: Apply the thermodynamic knowledge to understand the fundamentals of direct reduction and smelting reduction of iron oxides • CO2: Acquire the knowledge of reaction mechanism and the process technology of alternative routes of iron making • CO3: Learn to analyze raw materials requirements for different processes	
Topics Covered	Concept of alternative routes to Iron & Steel Making (3) Advent of the alternative methods of production (2) Consideration of local resources and other conditions with particular emphasis on Indianconditions (5) Classification of various DR processes (3) Raw materials and relevant considerations for various DR and SR processes (4) Techno-economic and environmental evaluation of DR and SR processes (4) Physico-chemical principles of reduction and smelting (8) Technology of production through solid reductant and gaseous reductants (7) Technological developments at various places worldwide (4)	
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. B. F. Ironmaking Principles -A.K Biswas 2. Direct Reduced Iron – Stephansion & Smailer 3. Modern Iron Making – R. H. Tupkery 4. Physical Chemistry of Iron & Steel manufacture – C. Bodsworth. <u>Suggested Reference Books:</u> 1.Beyond the Blast Furnace – Amit Chatterjee, CRC Press, USA. 2.Production of Liquid Iron Using Coal-Proc. of the Workshop, RRL, Bhubaneshwar,1964.	

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	3	1	1	1	1	1
CO3	3	1	1	1	1	1	3	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME613	Production of Ferroalloys	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC-301: Thermodynamics &		CT+EA					

Kinetics of Engineering Materials	
Course Outcomes	• CO1: Apply thermodynamic knowledge to understand the fundamentals of Ferro alloys production and their use • CO2: Acquire the knowledge of reaction mechanism and the process technology of production of different ferro alloys • CO3: Learn to analyze the different design aspects of submerged arc furnace
Topics Covered	Background for ferroalloy development and it's need for steel industry. [5] Trend of growth, as commensurate with steel growth. [5] Popular categories and reactions/mechanisms involved. [6] Processing Technologies for Ferrochrome/Ferromanganese/Ferrosilicon, etc. [6] Furnace details in terms of design/operation. [6] Processing of raw materials /reduction/melting/refining/casting, etc. [6] Case studies. [6]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. The Complete Book on Ferroalloys by B.P Bhardwaj, NIIR PROJECT CONSULTANCY SERVICES Publisher, 2014. 2. Production of ferroalloys: electrometallury, V. P. Elı͡u︡tin, State Scientific and Technical Pub. House for Literature on Ferrous and Nonferrous Metallurgy, 1957. <u>Suggested Reference Books</u>: 1. Production of ferroalloys, by M. Riss, Y. Khodorovsky, Mir Publishers, 1967. 2. Production of ferroalloys: electrometallurgy, by V.P. Elyutin, Israel Program for Scientific Translation, 1961.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	2	1	1	1	1	1
CO3	3	1	3	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME615	Ceramic Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC302		CT+EA					
Course Outcomes	CO1: Describes generic classification of ceramics and their specific engineering applications. Emphasis is put on such engineering ceramics, which are traditionally and commercially important as well as new advanced ceramics. CO3: Learn various techno-economic aspects of ceramics						

	CO4: Learn structure-property relationships, and solve problems of fabrication of high performance ceramic parts
Topics Covered	**Introduction**: Knowledge of different ceramic materials [4 hours] **Structures of ceramics:** Atomic structure, crystal structures, oxide structure, silicate structure, other structures and polymorphism. [6 hours] **Structural imperfections:** Frankel defects, schottky defects, nonstoichiometry etc [4 hours] **Microstructure of ceramics:** Microstructure of different ceramic materials: Oxides, Carbides, Nitrides, Silicides, Borides, etc. Glass and Glass-ceramics [6 hours] **Properties of ceramics:** Physical, Mechanical, Electrical, Thermal and Magnetic properties of ceramics [6 hours] **Applications and processing of ceramics:** Glasses and glass ceramics, refractoties, and abrasives [6 hours] **Advanced and nanostructured ceramics:** Structure, properies and applications [4 hours] **Bioceramics:** Fundamentals of bioceramics and their applications [6 hours]
Text Books, and/or reference material	Text Books: 1. Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery: Physical Ceramics: Principles for Ceramic Science and Engineering, , John Wiley and Sons., 1996. Reference Books: 2. D.W. Richerson: Modern Ceramic Engineering, , CRC Press, Third Edition, 2005.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	3	2	1	1	1	1	3	1	1
CO2	3	3	1	3	1	2	3	1	1	1	1	1
CO3	3	3	1	3	2	1	3	1	3	1	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME616	Solidification Phenomena	PER	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
MMC501: Manufacturing Processes	CT+MT+EA
Course Outcomes	• CO1: Understand solidification theories to industrial processes • CO2: Predict microstructures as a function of process parameters. • CO3: Understand solidification of alloys in different industrial conditions
Topics Covered	Properties of metals and alloys before and during solidification. Surface phenomena. (2) Basic terms: surface energy, surface tension, Wetting angle. Wetting speed.

	Classification and influence of wetting. (4) Rapid solidification processes (RSP). Classification of high cooling rates. Conventional and unconventional effects. (2) Under cooling and recalescence. Amorphous state. Glaze-ability. (1) Processing of alloys in the semi-solid state. Rheology. Newton's law of viscosity. Newtonian and non-Newtonian materials. (3) Distribution of non-Newtonian materials, physical models of materials and their rheograms. The apparent viscosity. Thixotropy.. Submersible rotational viscometry. (3) High-speed mixing. The intensity of the flow and its significance for the primary crystallization. The materials in the semi-solid state - SSM (Semi-Solid Metals). (2) Theories of solid solution morphology spheroidization. Types of alloys suitable for SSM. Case studies of selected castings. (4) Pressure solidification processes (PSP). Effect of pressure on the primary crystallization, change the thermo-physical properties, cooling rate and the force induced solidification flow. Alloys used in PSP. (3) Practical use of the rheological behavior of the alloys in the solidification processes and its importance. Case studies of selected castings. (4)
Text Books, and/or reference material	Suggested Text Books: 1. Principles of Solidification by Laurens Kagerman 2. Modelling the Flow and Solidification of Metals by T. A Smith 3. Physical Metallurgy- Principles and Practise by A Raghavan Suggested Reference Books: Kirkwood, D.H. – Suéry, M. – Kapranos, P. – Atkinson, H.V. – Young,K.P. Semi-solid processing of Alloys. Springer.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME617	Metal Joining Processes	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MMC501: Manufacturing Processes	CT + EA

Course Outcomes	CO1: Indicate which types of joining processes are suited for production. CO2: Determine various gas, arc, solid state, thermo chemical welding processes with their process parameters. CO3: Identify the various Weld Joints & Metallurgy
Topics Covered	Principles and theory, mechanism and key variables of different joining processes. (5) Soldering, brazing and welding processes types of tooling and equipment and consumables in welding. (6) Microstructures of fusion and HAZ: Carbon and alloy steels, corrosion resistance materials: stainless steels, aluminium alloys. Welding stresses. Heat flow in welding, chemical reactions in welding. Pre and post treatments advantages and disadvantages. (8) Weld joint consideration testing and inspection of weld joints. (6) Welding standard and specification. (5) Weldability field of application of the welding w.r.to gas welding, submerged arc welding, gas-tungsten arc welding, shielded metal arc welding, Plasma arc welding, flux core arc welding, electron beam welding, electro-slag welding, spot welding, laser welding, diffusion welding. (10)
Text Books, and/or reference material	Text Books: 1. Fabrication, Welding & Metal Joining Processes: A Textbook for Technicians and Craftsmen, C.R. Flood, Butterworths, 1981. 2. An introduction to Welding - R S Parmar 3. Principles of welding technology – L M Gourd, Edward Arnold / ELBS, London, 1980. Reference Books: 1. Welding for Engineers – H. Udin, E. R. Funk and J Wulff, John Wiley, New York. 2. Welding Engineering, B. E. Rossi, McGraw Hill New York 3. Welding Metallurgy, Sindo Kou, A John Wiley and Sons Incorporation Publication.

MME 617 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	2	1	2	1	3	2	1	1	1
CO2	2	1	1	2	1	1	1	3	1	2	2	1
CO3	1	1	2	2	2	3	1	3	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS651	Mineral Beneficiation Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC303: Non- Ferrous Process Metallurgy		CT					
Course Outcomes	• CO1: Correlate crushing of a material with different crushers • CO2: Separation of fines from different fraction and measuring efficiency • CO3 : Separation of sulphide ores by froth floatation unit						
Topics Covered	Experiment -1: Crushing of material in Jaw crusher followed by Roll Crusher Experiment-2 : Crushing the product of Roll Crusher in ball Mill Experiment-3 : Sieve shaking of the fines generated from Ball Mill Experiment-4 : Separation of Micro fines in a Cyclone Separator Experiment-5 : Froth Floatation Experiment-6 : Jigging Experiment-7 : Magnetic separation of metallic fines Experiment-8 : Separation of Material in a double-decker screen.						
Text Books, and/or reference material	Suggested Text Books: 1. Extraction of nonferrous metals, H.S. Ray, R.Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007). 2. W.H. Dennis, Extractive Metallurgy, Philosophical Library, New York (1965) Suggested Reference Books: 1. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	1	3	1	1	1	1	1	1	1	2
CO2	3	3	2	3	1	1	1	1	1	1	1	2
CO3	3	3	2	3	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS652	Mechanical Working of Materials Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Nil		EA
Course Outcomes	CO1: To know about the methods of rolling, forging under different conditions CO2: To learn the parameters needed to be controlled in rolling, forging processes CO3: To assess and understand the factors affecting the quality of the products	
Topics Covered	1. Hot rolling to produce round bars (merchant product) from square stock using grooved rolls and evaluating changes in microstructure and hardness 2. Cold rolling to produce sheet from plate using plain barreled rolls and evaluating changes in microstructure and hardness. Estimation of angle of contact, no-slip angle, forward slip, interfacial frictional coefficient, rolling load, rolling torque and horse power based on the process data 3. Open-die forging operation by hydraulic press and analysis of process data. Evaluation of hardness and microstructural changes of the forged product 4. Closed-die forging operation by hydraulic press and analysis of process data. Evaluation of hardness and microstructural changes of the forged product 5. Hot forging and cold forging of a given ductile (metallic) material and evaluation of hardness and microstructural variations 6. To study the effect of friction and lubrication in open-die cold forging operation	
Text and/or reference material	• Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill Book Company (UK) Limited, 1988 • The Rolling of Strip, Sheet and Plate, 2nd Edition, *E.C. Larke,* Chapman and Hall, Ltd., 1963	

CO-PO Mapping

POs COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	2	1	2	3		1		2	1	1	1
2	3	3	3	3	2	1	1		3	2	1	2
3	2	3	1	2	2	2	1	1	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS653	Materials Characterization Lab-I	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-403: Materials Characterization		CT+EA					
Course Outcomes	I. Learn fundamentals and operational aspects of X-ray diffraction, electron microscopy and other characterization techniques. II. In-hand identification of the crystal structure and indexing of diffraction patterns of different phases to meet contemporary needs. III. Data analysis and report writing of various experiments.						

Topics Covered	**List of Experiments** 1.Indexing the X-ray diffraction (XRD) pattern of different phases. (a). Indexing the XRD pattern of BCC structure. (b) Indexing the XRD pattern of FCC structure. (c) Indexing the XRD pattern of HCP structure. (d) Indexing the XRD pattern containing a mixture of BCC and FCC phase. 2.Precise lattice parameter determination. 3.X-ray diffraction of powders to show the effect of powder size on peak broadening. 4.Microstructural and Fractographic study by SEM. 5.Indexing of SADP 6.Precipitation kinetics study of age hardenable Al alloy 7.Characterization through atomic force microscope
Text Books, and/or reference material	Text Books: 1. "Elements of X-Ray Diffraction", by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968. 2. "X-ray diffraction-a practical approach", by C. Suryanarayana and M. Grant Norton, Springer, 1998. 3. "X-ray Diffraction: Its Theory and Applications", by **S. K. Chatterjee**, PHI. Limited,2004. *4. "Electron Microscopy in the Study of Materials"*, by *P.J. Grundy and G.A. Jones*, Arnold, London, 1976. 5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. **Williams** and C. Barry **Carter**, 2nd ed., Springer, 2009. 6. "Electron Microscopy and Analysis", by Peter J. Goodhew, John Humphreys and Richard Beanland, Third Edition, CRC Press, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	2	3	1	2	2		1	2	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

<table>
<tr><td colspan="9">DEPARTMENT OF MANAGEMENT STUDIES</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MSC-731</td><td>PRINCIPLES OF MANAGEMENT</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites- NIL</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1:To make budding engineers aware of various management functions required for any organization
CO2:To impart knowledge on various tools and techniques applied by the executives of an organization
CO3:To make potential engineers aware of managerial function so that it would help for their professional career
CO4:To impart knowledge on organizational activities operational and strategic both in nature
C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT I: Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization (8)
UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7)
UNIT III: Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8)
UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8)
UNIT V: Finance and Accounting: Basics of Financial management of an organization, Preparation of Financial accounting, Analysis of Financial statements, CVP Analysis, An overview of financial market with special reference to India .(12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
Financial Management, 11th Edition, I M Pandey, Vikas Publishing House.
Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India
Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education
Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India
Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey</td></tr>
</table>

<table>
<tr><td colspan="9">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core(PCR) / Electives(PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME710</td><td>Function alMateria ls</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MMC-302:Introductionto MetallurgyandMaterials</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr.S. Bera</td></tr>
<tr><td>CourseOut comes</td><td colspan="7">CO1: Learn thefundamentals ofdifferent kinds of functional materials
CO2: Types and applications of differentfunctional materials
CO3: Tutorials, problemsand solutionsetc.</td></tr>
<tr><td>TopicsCo vered</td><td colspan="7">Fundamentals of atomic structure- chemical bonding-crystal structure-property correlation;classificationofdifferentfunctionalmaterials. [6 hours]
Opto-electronic Materials: Optical properties of semiconductors, absorption and emissionprocesses,Electronic materials suchasGaAsandGaN. [6hours]
Sensor Materials: Metal oxide based sensors, Principles of operation, Solid electrolytesensors,Oxygensensors,OpticalSensors,ThermalSensorsandMagneticSensors,Thermistorsand relatedsensors. [6 hours]
Shape memory and Superelastic alloys: shape memory effect, thermodynamic aspects andmicromechanism of martensitic transformation, Stress induced martensitic transformationandsuperelasticity,Ni-TiandNi-Albasedalloysandtheirapplications. [8 hours]
Biomaterials:Conceptandassessmentofbiocompatibility,materialsforbiomedicalapplications:Ti-alloys,stainlesssteeletc. [8 hours]
Nanomaterials,Smartmaterials,Metalfoams,Nanofluids,Carbonnanotubes,MetalHydride,Hybrid nanocomposites,Nanoporous materials,Nanocoatings. [8 hours]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1.MaterialsScienceandEngineeringAnIntroduction–WilliamD.Callister,Jr.,John Wiley&Sons,Inc., 2007
2.Materials;Engineering,Science,ProcessingandDesign–MichaelAshby,Hugh Shercliffand DavidCebon
3.IntroductiontoMagnetic Materials–B. D.Cullity and C.D. Graham</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3		2	2	1	2	2	

CO2	3	1	1	2	3		2	2	2	3	2	
CO3	3	3	3	2	3	2	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME711	Fatigue, Creep and Fracture	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC-302: Introduction to Metallurgy and Materials		CT+MT+EA					
Course Outcomes	I. Learn fundamental and detailed understanding of fatigue, creep and fracture (including fracture mechanics). II. Solve problems on fracture, fatigue life, creep and different design problems to meet contemporary needs (including tutorials). III. Learn different applications and developments in fatigue, creep and fracture.						
Topics Covered	**Fatigue:** Types of stress cycles, S-N diagram and endurance limit, Various failure relations, viz., Goodman, Soderberg, Gerber parabola; Fatigue crack nucleation and propagation; application of fracture mechanics for fatigue cracking cyclic stress strain curve; low cycle fatigue; effect of stress concentration on fatigue; size effect; surface effects; effect of metallurgical variables on fatigue; Increased fatigue life due to surface protection cumulative fatigue damage rule; concept reverse plastic zone; corrosion fatigue; fretting; high temperature fatigue. 14h **Creep:** Materials problem at high temperature; time dependant mechanical behavior; Creep curves, Stress rupture test; Creep mechanisms; Deformation mechanism map; Super plasticity; Creep resistant alloys; Presentation of engineering creep data; Prediction of long time properties; Creep-fatigue interaction. 7 h**Fracture:** Examples of fracture in real components; Different design philosophies; atomic view of fracture; stress concentration effects of flaws; 2 h **Linear elastic plastic fracture mechanics (LEFM):** Griffith's theory of brittle fracture; The energy release rate; R-curve; Different modes of loading; Stress analysis of cracks, crack tip plasticity; concepts of plane stress and plane strain. 10 h **Elastic plastic fracture mechanics:** CTOD, J integral, HRR singularity; 4 h Types of fracture in metals; microstructural aspects of fracture; Different toughening mechanisms; 2h **Fracture toughness testing of metals:** K_{1C}, CTOD and J_{1C}. 3h						
Text Books, and/or reference material	Text Books: 1. “Elements of X-Ray Diffraction”, by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968. 2. “X-ray diffraction-a practical approach”, by C. Suryanarayana and M. Grant Norton, Springer, 1998.						

	3. "X-ray Diffraction: Its Theory and Applications", by **S. K. Chatterjee**, Prentice-Hall of India Pvt. Limited,2004. 4. *"Electron Microscopy in the Study of Materials"*, by *P.J. Grundy and G.A. Jones*, Arnold, London, 1976. 5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. **Williams** and C. Barry **Carter**, 2nd ed., Springer, 2009. 6. "Electron Microscopy and Analysis", by **Peter J. Goodhew**, **John Humphreys** and **Richard Beanland**, Third Edition, CRC Press, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	1		1	2	2		2	1	1	1	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Metallurgical & Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME712</td><td>Computational Materials Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the different methodologies of materials modelling and simulation
CO2: To explore materials structure, properties, and behaviour under externally imposed variables
CO3: To design materials for different applications</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction: Overview of different modeling approaches; aims and scopes; concept of multiscale modeling and simulation; significance of materials modeling and simulation.
[2 h]
2. DFT Modeling: Quantum Mechanics principles; Schrodinger's wave equation; waves and wave functions; solution of Schrodinger's wave equation; electron density; Hohenberg-Kohn theorems; Kohn-Sham approach; Kohn-Sham equations; exchange-correlation functionals; local density approximation; generalized gradient approximation; solution of Kohn-Sham equations; treating solids with pseudopotential approach; Bloch's theorem; plane wave expansions.
[12 h]
3. Atomistic Modeling: Classical Newtonian mechanics; overview of molecular dynamics (MD) simulation and its field of applicability; statistical mechanics principles; N-body problem; ensembles and ergodicity; interatomic potentials; initialization and thermal equilibration; boundary conditions; force calculation; potential energy cut-off and truncation schemes; integration algorithms with their relative merits and demerits; thermostatting; barostatting; evaluation of different physical, mechanical, structural,</td></tr>
</table>

	thermodynamic, and transport properties of materials using MD simulation technique; illustration of equilibrium MD and non-equilibrium MD techniques; MD exercises with LAMMPS; overview of probability theory based Monte Carlo (MC) simulation and its field of applicability; Metropolis algorithm; Kawasaki dynamics; kinetic Monte Carlo method; simulation of phase evolution and phase transformation using Monte Carlo method. [16 h] **4. Stochastic Simulation:** Overview; Brownian dynamics; modeling diffusion of a particle in a fluid medium. [4 h] **5. Continuum Modeling:** Overview; types; outline of continuum modeling using FEM technique; illustration of solving structural mechanics and heat transfer problems using FEM simulation. [5 h] **6. Multiscale Approaches:** Overview and examples; bridging the scale gaps between different simulation levels; simultaneous integration of models; sequential integration of models (hierarchical approach); illustration of coupled MD-MC model, coupled MD-FEM model, coupled MD-stochastic model. [5 h]
Text Books, and/or reference material	• Understanding Molecular Simulation*: D. Frenkel and B. Smit*, Academic Press, 2002 • The Art of Molecular Dynamics Simulation: *D.C. Rapaport*, Cambridge University Press, 2004 • Statistical mechanics: *Donald A. Mcquarrie*, Harper Row, 1976 • Handbook of Materials Modeling: Ed.: *Sydney Yip*, Springer, 2005 • Monte Carlo Methods in Statistical Physics, *M.E.J. Newman and G.T. Barkema,* Clarendon Press, 1999 • Density functional theory of atoms and molecules, *R. G. Parr and W. Yang,* Oxford University Press, 1989 • Electronic Structure of Materials, *A. P. Sutton,* Clarendon Press, 1994 • An Introduction to the Finite Element Method, *J.N. Reddy,* Mc-Graw Hill, 2006 • Materials Modelling using Density Functional Theory: Properties and Predictions,*F. Giustino,* Oxford University Press, 2014

CO-PO Mapping

POs COs	1	2	3	4	5	6	7	8	9	10	11	12
1	✔	✔	✔	✔	✔				✔			✔
2	✔	✔	✔	✔	✔	✔	✔		✔			✔
3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME713	Fuel, Furnace and Refractories	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC-301: Thermodynamics		CT+MT+EA					

& Kinetics of Engineering Materials	
Course Outcomes	• CO1: Understanding the Conventional and Non- Conventional energy sources • CO2: Understanding the property of Fuel and Refractories. • CO3 : Understanding the design of furnace with respect to usage of fuel and Refractories
Topics Covered	Definition, Comparative study of solid, liquid and gaseous fuels. Constitution, classification and grading of coal. (4) Testing of fuels like: Grindability, Caking properties, calorific value, Proximate and ultimate analysis, Flash and Fire point, viscosity. (6) Non-conventional Energy Resources like Nuclear fuel, Solar, Wind, Geo-thermal, Bio-mass, Hydrogen (2) Carbonization of coal: Coke making and by-products. (2) Producer gas, Water gas, Natural gas, LPG, Industrial Gases, Gobar Gas. Storage of fuels. (2) Combustion of fuels and problems (2) Definition and Classification of Furnaces, Batch furnaces, Continuous furnaces. (2) Construction and working of furnaces Pit furnace, Rotary furnace, Muffle furnace etc. (4) Evolution of heat and flame temperature. Available heat. Natural, forced, induced and balanced draft. Chimney height, (2) Heat losses in furnaces and minimization. Waste heat recovery. (2) Nature and Type and Properties of Refractories, Manufacture of Common Refractories (4) Furnace Design: Lay out of Refractories in a furnace. (2)
Text Books, and/or reference material	Suggested Text Books: 1. Elements of Fuels, Furnaces and Refractories, O. P. Gupta, Khanna publication. 2. Fuels, Furnaces and Refractories, J. D. Gilchrist 3. Fuels, Furnaces, Refractories and Pyrometry,-A.V.K. Suryanarayana, B. S. Publication Suggested Reference Books: Industrial Furnaces - Vol. I & II, W. Trinks and M. H. Mawhiney, Wiley

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME714	Powder Metallurgy	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC302		CT+EA					

Course Outcomes	CO1: Learn science and technological aspects of the Powder Metallurgy Techniques. CO2: The contemporary need can be met by the ability to analyze the industrial processes. CO3: Solve problems of near net shape fabrication of powder metallurgy parts and explore powder-processing-property relationship
Topics Covered	**Introduction:** Historical perspective of Powder Metallurgy; The Future of Powder Metallurgy. [4 hours] **Fabrication of Powders:** Basics methods, Mechanical fabrication techniques; Electrolytic fabrication techniques, Chemical fabrication techniques, Atomization techniques. Production of Ferrous powders [8 hours] **Powder Characterization:** Experimental methods for measuring particle size, shape, distribution, surface area; Significance of true, apparent and tap densities of powders;Flow rate; compressibility and green strength; Characteristics of common ferrous powders [6 hours] **Mixing and Blending:** Dry Mixing, wet mixing; Powder Lubrication [4 hours] **Compaction:** Injection Molding; Fundamentals of Compaction; Influence of Material and Powder Characteristics on compaction. [6 hours] **Sintering Behavior:** Sintering fundamentals; Sintering Theory; Mixed Powder Sintering; Liquid Phase Sintering; Sintering Atmosphere, Sintering Furnaces; Full Density Processing. [8 hours] **Finishing Operations:** Machining; Heat Treatments; Surface Treatments [4 hours] **Applications:** Competitive Processes; Examples of Powder Metallurgy Applications and Properties. [4 hours]
Text Books, and/or reference material	TEXT BOOKS: 1. Powder Metallurgy – A Upadhyaya and G S Upadhyaya. 2. Powder Metallurgy Science – R. M. German, 2nd Edition, MPIF, 1994 REFERENCE BOOKS: 1. Powder metallurgy: principles and applications, Fritz V. Lenel, Metal Powder Industries Federation, 1980 2. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	1	1	1		3	1	1
CO2	3	3	1	1	1	2	3		1	1	1	1
CO3	3	3	2	1	2	1	2	1	3	1	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME715	Secondary Steel Making	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT), and end assessment (EA))
Metallurgical Thermodynamics and Kinetics, Transport Phenomena in Metallurgical Process	CT+MT+EA

Course Outcomes	CO1: Learn fundamentals of physico-chemical principles of Secondary steel making. CO2: Apply laws of thermodynamics and kinetics for producing clean steel. CO3: Design process route for economical production of steel.
Topics Covered	A brief review of fluid flow, thermodynamics and primary steel making processes, composition of the crude steel, need for secondary refining, the objective of secondary steel making, physico-chemical principles of Secondary steel making, Slag basicity and capacities, secondary steel making equipment and processes, preheating and recycling of ladles. (8) Furnace tapping operations; Phenomena during furnace tapping; carry over slag and slag detection devices; slag making in ladles and de-oxidation: common de-oxidisers and requirement of de-oxidisers; addition methodology; melting and dissolution of deoxidisers; de-oxidation thermodynamics and kinetics; simple vs. complex de-oxidation; De-oxidation products; Elementary de-oxidation calculations. (5) Inert Gas Stirring in Ladles (objectives, Devices, gas flow regimes, stirring energy and stirring intensity); Temperature and Composition Control in Ladles (arcing, alloying addition, and aluminium wire feeding). (3) Degassing and Decarburization in liquid steel: Introduction, Principles and thermodynamics of reactions in vacuum degassing, equipment's and degassing Methods and their relative merits and demerits; slag eye area and re-oxidation, fluid flow and mixing in vacuum degassing, rates of vacuum degassing and decarburization, decarburization for Ultra-low carbon (ULC), stainless steel making. (8) Desulfurization in secondary steelmaking: Introduction, thermodynamics aspects, desulfurization with only top slag, injection metallurgy for Desulfurization. (3)

	Clean steel, Types of inclusions, Morphology, Properties of inclusions, Inclusion assessment, sources of inclusions, control of inclusions, Inclusion modification, Calcium Treatment (cored wire injection. objectives and devices reactions, calcium recovery and inclusion morphology and composition). (6) Teeming speed, Gas absorption during tapping and teeming form surrounding, Temperature changes of molten steel during secondary Steel making, phosphorus control in secondary steel making, Nitrogen control in steel making, application of Magnetohydrodynamics, Modeling of secondary steelmaking processes. (6)
Text Books, and/or reference material	Suggested Text Books: 9. Principles and Practices in Iron and Steelmaking – A. Ghosh, and A. Chatterjee. 10. Secondary Steelmaking – A. Ghosh Suggested Reference Books: 10. Making, Shaping and Treating of Steel (Steelmaking and Refining), 10th Edition, 1985, AISE, Pittsburgh

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1	1	1	1	1	1
CO3	3	2	3	3	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME716	Composite Materials	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-302: Introduction toMetallurgyand Materials		CT+EA					
CourseOutcomes	Learn the fundamentals of compositematerials,classification, properties and applications Metalmatric composites(MMCs) Solidand liquidstate synthesisofMMCs, joining of MMCs						

TopicsCovered	Course assessment methods: Mid semester examination and End semester examinationIntroduction:Classificationofcompositesonthebasisofmatrix,ex-situorin-situsynthesis,typeofreinforcementetc.;Metalmatrixcomposite,polymermatrixcomposites,ceramicmatrix compositeand carbon-carboncomposite; applicationofdifferentcompositematerials. (8 hours) Differentroutesofcompositesynthesis:castingroute,powdermetallurgyrouteandother routes. (4hours) PowdermetallurgyprocessedComposite:highenergymilling,Mechanicalalloying:Fundamentals and parameters; Compaction and Sintering: material dependent routes andprocess parameters; Recent trends- Spark plasma sintering, Equal channel angular pressingetc.;process parameter-structure-propertycorrelation. (12hours) Cast metal matrix composites: different synthesis routes: dispersion process (stir casting,compocasting and screw extrusion)-contact angle, wettability and particle-matrix bonding;Liquid metal impregnation/infiltration (pressure infiltration, squeeze casting and Lanxideprocess)- principle of molten metal infiltration-capillary flow ofmolten metal; Sprayprocess(Ospreyprocessandrapidsolidificationprocess);In-situproductionofdispersoids-XD process; evolved microstructure: structural defects in cast metal matrixcomposites-porosity,particlesegregation(macrosegregationandmicrosegregation),interfacialreactionand particledegradation;structure-propertycorrelation. (12 hours) Joiningofmetalmatrixcomposites,limitationsofconventionalfusionwelding,Applicationoftransientliquidphase(TLP)diffusionbonding,basicmechanismanddifferentstagesof TLPbondingprocessformonolithicandcompositesystem,processparametersofTLPbonding,joint efficiency. (4hours)
Text Books, and/or reference material	Text Books: 1. MetalMatrix Composites-Chawla and Chawla, Springer, 2006. 2.'Joiningofaluminiumbasedmetalmatrixcomposites'-JoydeepMaity,in'Engineered MetalMatrix Composites: Forming Methods, Material Properties and Industrial Applications',Editor:LucaMagagnin,2012,NOVASciencePublishers,Inc.,NewYork, USA,pp 329-354. 3.MaterialsScienceandEngineering:AnIntroduction-WilliamD.Callister,Jr.,John Wiley&Sons,Inc., 2007. 4.FundamentalsofMetal-MatrixComposites-AndreasMortensenandAlanNeedleman, Butterworth-Heinemann,1993. 5.AnIntroductiontoCompositeMaterials–DerekHull,CambridgeUniversityPress, 1981. 6.CompositeMaterials–DeborahD.L.Chung,Springer, 2009. 7.Metal-Matrixcomposite–P.K.Rohatgi,DefenceScienceJournal,Vol43,No4, October1993,pp 323-349. 8.Y. B.Liu, S. C.Lim, L. Lu,M. O. Lai,Recentdevelopment inthefabricationof metal matrix-particulatecomposites usingpowder metallurgy techniques,Journalof MateralsScience29(1994)1999-2007.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	-	2	2	1	2	2	3	3
CO2	3	-	2	2	-	3	2	-	-	-	3	3
CO3	3	2	3	2	3	-	-	1	2	1	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME717	Corrosion Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CYC-01: Engineering Chemistry		CT+EA					
Course Outcomes	CO1: To learn Fundamentals of Corrosion Engineering CO2: Techniques to acquaint with Actual Corrosion Testing CO3: To understand the Principles, Mechanism and Prevention of High Temperature Corrosion						
Topics Covered	Introduction: Definition of corrosion, Cost of Corrosion, corrosion damage, environments, and classification of corrosion. (1) Corrosion Principles: Electrochemical reactions, thermodynamics of corrosion, cell potential, emf and galvanic series, representation of cell / cell diagram, electrode kinetics, exchange current density, polarization - activation, concentration and combined, Pourbaix diagram, Evans diagram, Passivation. (11) Forms of Corrosion: Uniform attack; galvanic or two-metal corrosion; crevice corrosion; pitting corrosion; intergranular corrosion – sensitization and weld decay; Selective leaching - dezincification; erosion corrosion; Stress corrosion cracking (SCC) and hydrogen damage. Case studies of corrosion in industry e.g. steel, chemical, fertilizer and food etc. (11) Corrosion Prevention: Materials selection, alteration of environments, design, inhibitors, cathodic and anodic protection, coatings – electroplating. (5) Corrosion Testing: Purpose, standard expression of corrosion rate, polarization technique – Tafel extrapolation, linear polarization method, AC impedance method, evaluation of pitting damage, Huey and stretcher test for stainless steel, slow strain rate test (SSRT). Corrosion failure analysis. (5) High Temperature Corrosion: Introduction, oxidation, Pilling – Bedworth (PB) ratio, electrochemical and morphological aspects, oxidation kinetics, internal oxidation, corrosion in mixed environments, salt deposited hot corrosion, case studies for high temperature corrosion. (2)						

Text Books, and/or reference material	Text Books: 1. Corrosion Engineering – Mars G. Fontana, McGraw- Hill Publication, 1987. 2. The Fundamentals of corrosion – J. C. Scully Reference books: 1. An Introduction of Metallic Corrosion – R. Evans, Eward Arnold (Publishers) Ltd, London. 2. Introduction of High Temperature Corrosion – N. Birks and G. H. Meier

MME 717 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	1	2	2	1	3	2	2	2	1
CO2	1	1	3	2	2	2	1	2	2	2	2	1
CO3	1	1	3	1	1	2	2	2	3	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME-718	Energy and environment in metallurgical industries	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-301:Metallurgical Thermodynamics and Kinetics		CT+EA					
Course Outcomes	CO1: To give concept of effective utilization of energy in metallurgical processes. CO2: To provide knowledge regarding various pollutants and their methods of control in metallurgical industries. CO3: To learn the methods of minimization of energy requirements and prevention of energy loss CO4: To learn about the application of recycling methods of wastes materials generated in metallurgical industries						
Topics Covered	**UNIT I:** Energy: (14 hrs) Energy resources: non-renewable and renewable, Indian energy resources. Use of energy in metal production, process fuel equivalent. Conservation of energy in metallurgical industries with examples of aluminium, iron & steel making. Hydrogen energy: characteristics, production, storage and utilization in metal industries. **Biomass:** types of biomass, wood char as reductant in iron making.						

	UNIT II:(25 hrs) Environment: Sources and types of pollutants (wastes) from metal / minerals industries. Gaseous emissions: control of SPM, hazardous gases, viz. sulphur dioxide, fluorides, nitrogen oxides. Greenhouse gases: Greenhouse effect, global warming potential, Kyoto protocol, carbon trading. Emission and control from, iron & steelmaking and aluminium smelting. Liquid effluents: treatment of waste water, with examples from metal industries. Solid wastes: types, disposal and utilization of slime, red mud and spent pot lining, iron and steel slags. Impact of pollutants on human health, management of radioactive wastes,e-waste, noise pollution, thermal pollution.
Text Books, and/or reference material	**Text Books:** 1. R.C.Gupta: Energy and Environmental Management in Metallurgical Industries, PHI Learning 2. H.S.Ray. B.P.Singh, S.Bhattcharya, V.N.Misra,. Energy in Mineral and Metallurgical Industries, Allied Publisher 3. C.S.Rao: Environmental Pollution Control Engineering, Wiley Eastern Ltd. 4. J.A.Nathanson: Basic Environmental Technology, prentice-Hall India **Reference Books:** 1. R.C. Gupta(ed.): Proc. Environmental Management in Metallurgical Industries(EMMI-2000),Allied Publishers 2. R.C. Gupta(ed.): Proc. Environmental Management in Metallurgical Industries(EMMI-2010),Allied Publishers 3. Fathi Habashi: Pollution Problems in Mineral and Metallurgical Industries, Metallurgie Extractive Quebec. 4. H.S.Peavy et al.: Environmental Engineering, McGraw Hill

POs vs. COs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	1	2	2	1	1	1	1	1
CO2	3	1	1	1	1	2	3	1	1	1	1	1
CO3	3	3	2	2	2	3	3	1	1	3	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS751	Manufacturing Processes Lab - II	PCR	0	0	1	4	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC403 and MMC501		CT+EA					
Course Outcomes	CO1: Learn science and technological aspects of the Powder production and characterization						

	CO2: To study the effect of compaction pressure on densification and learn various sintering techniques to produce net shape product CO3: Explore powder-processing-property relationship through laboratory assignment.
Topics Covered	Exp 1: Demonstration of ball milling, compaction unit, dynamic light scattering technique and tube furnace [3 hours] Exp 2: Synthesis of nano powders by Chemical reduction [3 hours] Exp 3: Particle reduction by Ball milling [3 hours] Exp 4: Characterization of nano and milled powders [3 hours] Exp 5: Particle size analysis by different techniques [3 hours] Exp 6: Conventional die compaction of powders [3 hours] Exp 7: Solid state sintering [3 hours] Exp 8: Liquid phase sintering [3 hours] Exp 9: Microstructural characterization and phase analysis of sintered products [3 hours] Exp 10: Hardness measurement of sintered products [3 hours]
Text Books, and/or reference material	TEXT BOOKS: 1. Powder Metallurgy – A Upadhyaya and G S Upadhyaya. 2. Powder Metallurgy Science – R. M. German, 2nd Edition, MPIF, 1994 REFERENCE BOOKS: 1. Powder metallurgy: principles and applications, Fritz V. Lenel, Metal Powder Industries Federation, 1980 2. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	2	3	1	2	2		1	2	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS752	Materials Characterization Lab - II	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

MMC-503: Fundamentals of Plastic Deformation and Strengthening of materials	CT+EA
Course Outcomes	I. Learn fundamentals and operational aspects of wear, non-destructive and other testing techniques. II. In-hand interpretation of wear mechanisms and fractographs of different materials to meet contemporary needs. III. Data analysis and report writing of various experiments.
Topics Covered	**List of Experiments:** 1. Materials Characterization Using Non Destructive Testing (NDT) Methods: (a) Magnetic particle testing (b) Dye penetrant test. (c) Ultrasonic technique 2. Tribological study and worn surface characterisation of different materials using: (a) Pin-on-disk wear testing machine. (b) High stress abrasive wear testing machine. 3. Effect of strain rate on tensile behaviour and fracture surface of different materials 4 Determination of fracture toughness by indentation technique
Text Books, and/or reference material	Text Books: **1. Mechanical Metallurgy by George Dieter**

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	2	3	1	2	2		1	2	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS753	Ferrous Process Metallurgy Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC303: Non- Ferrous Process Metallurgy		CT					

Course Outcomes	• CO1: Understand the method of agglomeration of iron ore fines by sintering and pelletization • CO2: Study the fluid dynamics in a cold model of B.O.F • CO3: Evaluate the properties of agglomerates
Topics Covered	Experiment -1: Sintering of iron ore fines in laboratory Sintering Machine Experiment-2: Pelletization of iron ore fines in a disc pelletizer Experiment -3: Measure the properties of sinter produced Experiment-4: Measure the green and indurated properties of pellets Experiment -5: Briquetting of iron ore fines. Experiment-6: Study the effect of velocity and nozzle diameter and no of nozzles on the diameter and depth of Crater formed in a water model of LD Converter
Text Books, and/or reference material	Suggested Text Books: 1. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008. 2. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	1	1	1	1	1	1	1	2
CO2	3	3	2	3	1	1	1	1	1	1	1	2
CO3	3	3	2	3	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EIGHTH SEMESTER

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME810	Nano Science and Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC302: Introduction to Metallurgy and Materials		CT+EA					

Course Outcomes	CO1: To gain fundamental knowledge about the nanomaterials and their properties CO2: To learn about various techniques of the synthesis and characterization of nanomaterials CO3: To explore the various applications of nanomaterials
Topics Covered	1. Introduction: Basics of nano-scale, History of nano-technology, Uses of technology (natural and manufactures) in nano-scale, advantages and disadvantages. [6 h] 2. Nano-materails, Different types of nano-materails. Uses of current technology. [4 h] 3. Basics of mechanical, electrical, magnetic and optical properties of materials. Effect of miniaturization (nano-scale) on mechanical, electrical, magnetic and optical properties of materials. [12 h] 4. Synthesis of nano-materials (different synthesis routes: top down and bottom up approach), Characterization of nano-materials by different techniques. [12 h] 5. Application of nanomaterials, effect on daily life, environmental effects. [6 h]
Text Books, and/or reference material	Text Books: 1. Materials Science and Engineering: An Introduction - William D. Callister, Jr., John Wiley & Sons, Inc., 2007 2. Nanomaterials Nanotechnologies and Design – D.L. Schodek, P. Ferreira, M.F. Ashby, Butterworth-Heinemann, 2009 3. Introduction to Nanotechnology – C.P. Poole, F.J. Owens, Wiley Interscience, 2003

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	-	-	-	1	1	-	3
CO2	3	3	3	3	3	2	1	-	1	1	-	3
CO3	2	2	1	2	1	3	3	-	1	1	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME811	FEM Modelling and Simulation for Materials Design	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
XEC01: Engineering Mechanics, MMC503: Fundamentals of Plastic Deformation and Strengthening of Materials	CT+EA

Course Outcomes	CO1: To understand the basics and methodologies for FEM modelling and simulation CO2: To explore materials mechanical behaviour under externally imposed variables CO3: To design materials for different structural applications
Topics Covered	1. **Introduction:** Overview of different continuum modelling techniques - finite element method (FEM) modelling and simulation - advantages and drawbacks of the method; types and applications of the method. [4 h] 2. **Basics of FEM modeling and simulation:** General steps; different approaches for deriving element properties: direct approach, variational approach, and Galerkin's method; types of elements and interpolation functions and their applicability; condensation and substructuring; continuity requirements; mesh refining; Gauss quadrature; FEM modelling for structural and thermal problems. [32 h] 3. **Applications:** Structural design; stress mapping; heat transfer; temperature mapping; FEM based design of composite materials; study of deformation of materials under different loading conditions. [10 h]
Text Books, and/or reference material	• The Finite Element Method for Engineers, 4th Edition: *Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, and Ted G. Byrom,* Wiley, 2001 • An Introduction to the Finite Element Method, 3rd Edition: *J. N. Reddy,* Mcgraw Hill Series in Mechanical Engineering, 2005

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME812	Mathematical Modelling and Simulation	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))

Transport Phenomena in Metallurgical Process	CT+MT+EA
Course Outcomes	CO1: Learn fundamentals of Modelling. CO2: Identify nature of engineering problems and solving by numerical methods CO3: Build physical and mathematical models to describe the complex physical phenomena pertaining to real world.
Topics Covered	Review of Fluid Flow, heat transfer and Mass transfer, Type of Models, Advantages of Mathematical Model, Types of Mathematical model, Method of prediction, Modeling vs. experimentation, nature of coordinates. (3) Classification of partial differential equations, Elliptic, Parabolic, and Hyperbolic Equations, Initial and Boundary Conditions, Initial Value and Boundary Value Problems, Substantial derivative, Concept of grid points, cell and mesh, methods of discretization, Types of cells and mesh, Basic approach in solving a problem. (4) Central, Forward, and Backward difference expressions for a uniform grid, Central difference expression for a nonuniform grid, Numerical errors, Accuracy of solution: optimum step size, grid Independence test. (3) Application heat of conduction and diffusion, one dimensional steady state problem, Method of solution: Gaussian elimination, Tri-diagonal matrix algorithm (TDMA), Gauss-Seidel iterative method, the concept of Relaxation factor, optimization of Relaxation factor, Two-dimensional steady state problem, Block iterative methods, There-dimensional steady state problem, Transient one dimensional problem, Euler method, Crank-Nicolson method, Pure Implicit method, Accuracy of Euler, Crank-Nicolson and Pure Implicit method, stability, Von Neumann stability analysis, Two-dimensional transient, Alternative Direction Implicit method, Problem in cylindrical and spherical geometry, Non-axissymmetric problem, Transient conduction in composite media, Treatment of non-linierities in conduction and diffusion, irregular geometry, Diffusive- convective system with Flow, Met lab codes. (22) Physical modeling: Introduction, dimensional analysis, similarity criteria, modeling of steel making processes. (4) Application related to metallurgical processes (3)
Text Books, and/or reference material	Suggested Text Books: 11. Finite difference Method in heat transfer- M. N. Ozisik 12. Computational Fluid dynamics and heat transfer – P.S. Ghoshdastidar 13. Modeling of Steelmaking Processes – D. Mazumdar and James W. Evans Suggested Reference Books: 11. Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers– R. Pratap. 12. Numerical Methods for Engineers - D. Vaughan Griffiths and I.M. Smith.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	2	2	2	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME-813</td><td>Raw materials preparation for iron and steel making</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC-502: Iron making</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To acquire ideas of preparing raw materials as burden for different iron and steel making methods.
CO2: To learn about the different processing routes for raw materials preparation
CO3: To learn about the application of different testing methods of raw materials in context to iron and steel making</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Need of Raw Material Preparation. [1hr]
Ore Preparation: Important minerals and their characteristics; Ore reserves in India and World; Techno - economic appraisal of ore- breaking, crushing and grinding techniques considering sizing operations. [8hrs]
Agglomeration: Purpose, technological appraisal of various methods with merits and demerits, bonding mechanism. [3hrs]
Sintering: Process, mechanism, factors affecting sinter quality, fluxed sinter, sinter mineralogy, sintering machine design, process control.[5hrs]
Pelletizing: Process, green ball formation and growth, additives and their effect, pellet drying and hardening (cold and hot), pelletizing machine types, design, pellet firing systems. [6hrs]
Briquetting and Nodulizing: Process, additives and hardening methods. Rotary hearth furnace, its operation, future prospective. Techno- economic evaluation of various iron ore feed materials. [4hrs]
Coal preparation: Coal washing purpose and methods, use of coal in iron and steel making [6hrs]
Coke quality: Stamp charging, coke quality affected by process parameters, coke testing, methods for reactivity, strength etc. [4hrs]
Industry status: Agglomeration scenario in India and world, coking coal in India and world, future prospects. [1hr]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text books:
1. O.P. Gupta: Elements of Fuels, Furnaces and Refractories, Khanna Publishers (Delhi).
2. J.D. Gilchrist: Fuels, Furnaces and Refractories, Pergamon.
3. RC Gupta : Theory and laboratory experiments in ferrous metallurgy,PHI, New Delhi
4. R.H. Tupkary: Introduction to Modern Iron Making, Khanna Publishers.
5.A. Ghosh, Amit Chatterjee: Ironmaking and Steelmaking: Theory and Practice, PHI, New Delhi
Reference books:
1. Efficient Use of Fuel, HMSO (London).</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	3	1	1	1	1	2	2	1	1	1	1	1
CO2	3	3	2	2	2	3	3	1	1	3	3	3
CO3	3	3	3	3	3	3	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME814	Experimental Techniquesin Metallurgy	PEL	3	0	0	3	3
Engineering Physics (PH 01)		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Engineering Physics		CT+MT+EA					
Course Outcomes	CO1: To understand the principle and theory of different experimental techniques CO2: To understand the mechanisms used to measure the different properties of materials using different techniques. CO3: To learn science and technological aspects of different experimental techniques used for materials						
Topics Covered	OpticalMethods:Fundamentalofimageformation,Differentaberrationinoptical systems, Opticalmicroscopy,characteristic ofmicroscope,differentconditionsof imageformation suchas brightfield,darkfield, obliqueillumination. Special TechniquesinMetallography:Polarizedbeam,Phase Contrast,Differential Interference Microscopy,Fluorescent's microscopy,Principles of above techniques andtheirapplications.QuantitativeMetallurgy andImageanalysis,Applications Developments forQuantitativeImage analysis in Metallurgy. [10 hrs] BasicprincipleofScanningElectronMicroscopy (SEM),TransmissionElectron Microscopy (TEM),secondary electron,backscatteredelectron,Diffractionpattern analysis,energy dispersiveX-ray spectroscopy(EDS),Wavelengthdispersive spectrometeranalysis(WDS),electron backscattereddiffraction(EBSD), electron probe microanalysis(EPMA).FundamentalofAtomic Force microscopy,Basic theory,Imageformationand its applications.[8 hrs.] Techniquesfor chemical analysis:Atomic absorption spectrometer,Emission spectroscopy&directreadingspectrometer, Mass spectrometer. Principle of temperature measurement by suing thermocouple and radiation pyrometers. [4 hrs.] Thermalanalysisofphase transformations: Thermal Analysis techniques: Principle, Working andapplicationofDTA,TGA,DSCandThermo-MechanicalAnalysis, Principles and Applications. [2 hrs.] Principle of magneticcharacterization, characterization of soft magnetand hard							

	magnets.Application. [4 hrs.] NDT:BasicprincipleofDye Penetranttesting,Typesofdyemethodsand application,Developer applicationandInspection,Magneticparticletesting,Basic theory ofmagnetism,Magnetizationmethods,Fieldindicators,Particleapplication, Inspection.Eddy currenttesting,Basicprinciple;Faraday'slaw,Inductance, Ultrasonic testing:Basicsofultrasonicwaves,Pulseandbeamremarks, Radiographictesting,Basics,differentisotopesanddifferenttechniquestoidentify the flaws. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. ExperimentalTechniquesinPhysicalMetallurgy,V.T.Cherepin&A.K. Malik, I.I.T., Bombay. 2. Thermal Analysis byBernhard WiindrelichAcademic Press. 3. ImageAnalysis &Metallography.(MicrostructuralScienceVol.-17)ASTM 1989. 4. 1.F.Weinberg,Editor,Tools&TechniquesinPhysicalMetallurgy,Vol.I& Vol.II, Marcel Dekker, 1970. Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2	2	3
CO2	3	3	3							2	2	3
CO3	3	3	2							2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY / DUAL DEGREE / INTEGRATED M.Sc PROGRAM

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects 27-06-2019

V2:

Rectification of minor errors UGAC 31-08-2022

Final Approval in _____ Senate # _______________ # Item no: ______

DEPARTMENT OF BIOTECHNOLOGY

Program Name: Bachelor of Technology and Master of Technology (Dual Degree) in Biotechnology

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR BIOTECHNOLOGY-B.TECH. AND M.TECH (DUAL DEGREE)
L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week
C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CHC331	Process Calculation and Thermodynamics	3	1	0	4.0	4
3	BTC301	Cell biology and Genetics	3	1	0	4.0	4
4	BTC302	Microbiology and Bioprocess Technology	3	1	0	4.0	4
5	BTC303	Biochemistry and Enzyme Technology	3	0	0	3.0	3
6	BTS352	Biochemistry Laboratory	0	0	3	1.5	3
7	BTS 351	Microbiology Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BTC401	Molecular Biology and Recombinant DNA Technology	3	1	0	4.0	4
2	CHC431	Unit Operation of Chemical Engineering- I	3	1	0	4.0	4
3	BTC402	Immunology	3	1	0	4.0	4
4	CSC431	Programming and Data Structure	3	0	0	3.0	3
5	YYO44*	Open Elective - 1	3	0	0	3.0	3
6	BTS451	Cell Biology and Genetics Laboratory	0	0	3	1.5	3
7	CHS481	Unit Operations of Chemical Engineering- I Laboratory	0	0	3	1.5	3
8	CSS481	Programming and Data Structure Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BTC501	Biochemical Reaction Engineering and Bioreactor Design	3	1	0	4.0	4
2	BTC502	Cell and Tissue Culture	3	1	0	4.0	4
3	BTC503	Bioseparation and Biochemical Analysis	3	1	0	4.0	4
4	CHC531	Unit Operations of Chemical Engineering- II	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	BTS551	Immunology Laboratory	0	0	3	1.5	3
7	BTS552	Bioprocess Technology Laboratory	0	0	3	1.5	3
8	CHS581	Unit Operations of Chemical Engineering Laboratory- II	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	15	4	9	23.5	28

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	BTC601	Bioinformatics	2	1	0	3.0	3
3	CSC631	Database Management System	2	1	0	3.0	3
4	CHC631	Process Control and Instrumentation	2	1	0	3.0	3
5	BTE61*	Depth Elective - 1	3	0	0	3.0	3
6	BTE61*	Depth Elective - 2	3	0	0	3.0	3
7	BTS651	Molecular Biology and rDNA Technology Laboratory	0	0	3	1.5	3
8	BTS652	Bioinformatics Laboratory	0	0	3	1.5	3
9	CSS681	Database Management System Laboratory	0	0	3	1.5	3
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - VII							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	BTC701	Modern techniques in Biotechnology	3	1	0	4.0	4
3	BTE71*	Depth Elective - 3	3	0	0	3.0	3
4	BTE71*	Depth Elective - 4	3	0	0	3.0	3
5	YYO74*	Open Elective - 4	3	0	0	3.0	3
6	BT1002	Bioprocess Engineering	3	1	0	4.0	4
7	BTS751	Bioseparation and Biochemical Analysis Laboratory	0	0	3	1.5	3
8	BTS752	Cell and Tissue Culture Laboratory	0	0	3	1.5	3
9	BTS753	Biochemical Reaction Engineering Laboratory	0	0	3	1.5	3
10	BTS754	Vocational Training /Summer Internship and Seminar	0	0	2	1.0	2
11	BTS755	Project – I	0	0	3	1.0	3
		TOTAL	18	2	14	26.5	34
Semester - VIII							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BT90XX	Depth Elective - 5	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	BT2001	Genomics , Proteomics and Bioinformatics	3	1	0	4.0	4
5	BT2053	Omics and Bioinformatics Lab	0	0	4	2.0	4
6	BTS855	Thesis Project - I	0	0	6	2.0	6
		TOTAL	12	1	10	17	23

CURRICULUM AND SYLLABUS FOR DUAL DEGREE PROGRAM IN BIOTECHNOLOGY

Semester - IX							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	BT90XX	Depth Elective-6	3	0	0	3.0	3
2	BT90XX	Depth Elective -7	3	0	0	3.0	3
3	BT1051	Bioprocess Engineering Laboratory	0	0	4	2.0	4
4	BT3055	Major Project-I	0	0	22	11.0	22
5	BT3056	Major Project Seminar- I	0	0	0	3.0	0
		TOTAL	6	1	26	22.0	33
Semester - X							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BT4055	Major Thesis Project - II	0	0	22	11.0	22
2	BT4056	Major Project Seminar-II & Viva Voce	0	0	0	3.0	0
3	BT4057	Comprehensive Viva Voce	0	0	0	1.0	0
		TOTAL	0	0	22	15.0	22

CREDIT UNIT OF THE PROGRAM:

Semester	**I + II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**TOTAL**
Credit Unit	38.0	22.0	22.5	23.5	22.5	26.5	17.0	22.0	15.0	209.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF BIOTECHNOLOGY
BTE610	Animal Biotechnology
BTE611	Industrial Microbiology
BTE612	Nutraceutical and Nutrigenomics
BTE613	Human Genomics
BTE614	Molecular Virology
BTE615	Biometallurgy
BTE616	Nanobiotechnology
BTE617	Marine Biotechnology
BTE618	Folding, Misfolding and Diseases
BTE619	Engineering Resistance in Plants

7th Semester

	DEPARTMENT OF BIOTECHNOLOGY
BTE710	Molecular Plant Pathology
BTE711	Cancer Biology & Cell Signaling
BTE712	Food Biotechnology
BTE713	Biopharmaceutical Process Design
BTE714	Bioenergy
BTE715	Project Engineering for Biotechnology
BTE716	Structural Biology
BTE717	Environmental Biotechnology
BTE718	Proteomics and Protein Engineering
BTE719	Molecular Modelling & Drug Design
BTE720	Nanotherapeutics
BTE721	Biomaterials
BTE722	Vaccine Technology
BTE723	Stem Cell Biology
BTE724	Application of Molecular Cloning

8th / 9th Semester

	DEPARTMENT OF BIOTECHNOLOGY
BT9031	Human Molecular Genetics
BT9032	Cancer Biology
BT9033	Signal Transduction
BT9034	Molecular Cell Signalling
BT9035	Food Biotechnology
BT9036	Biopharmaceutical Technology
BT9037	Biomaterials
BT9038	Biomettalurgy
BT9039	BioEnergy
BT9040	Bioprocess & Plant design
BT9041	Advanced rDNA & Cellular Biotechnology
BT9042	Animal Biotechnology
BT9043	Immunotechnology
BT9044	Molecular Modelling & Drug Design
BT9045	Regenerative Medicine & Translational Research
BT9046	Microbial Biotechnology
BT9047	Environmental Biotechnology
BT9048	Protein structure, folding & misfolding
BT9049	Methods in Computational Biology

BT9050	Nanobiotechnology
BT9051	Plant Biotechnology
BT9052	Metabolic Engineering
BT9053	Nutraceuticals & Nutrigenomics
BT9054	Molecular Plant Pathogen Interactions
BT9055	Cell Biology of Human Diseases
BT9056	Infectious Diseases & Infection Control
BT9057	Project Engineering in Biotechnology
BT9058	Biological Computation
BT9059	Quality by design for Biopharmaceuticals
BT9060	Medical Biotechnology
BT9061	Biological Chemistry
BT9062	BioEntreuprenerurship

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I								
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of function, limit, differentiation, and integration.	CT+MT+EA

Course Outcomes	
	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence

Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.						
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]						
Text Books, and/or	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech						

reference material	Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis						

	using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	<u>Suggested Text Books:</u> (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall <u>Suggested Reference Books:</u> **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan

	Inorganic Chemistry: (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application						
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5]						

	Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its						

	implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment					

	(EA))
None	CT+EA
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end					

	assessment (EA))
NIL	CE+EA
Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.						

Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	WORKSHOP PRACTICE	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Study and practice on machine tools and their operations • CO2: Practice on manufacturing of components using workshop trades						

	including fitting, carpentry, foundry and welding • CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping • CO4: Develop basic electrical engineering knowledge for house wiring practice
Topics Covered	**M/c shop & Carpentry shop -- 3X3= 9hrs.** • Introduction on machining process. • Introduction to machine tools- Lathe, Shaper, Milling and Drill machine. • Introduction to woods- Types, structure, disease and defect of wood. • Introduction to wood working machines and tools. • Making of dovetail joint and bridle joint. **Welding Shop & Sheet metal -- 3X3= 9hrs.** • Introduction to welding.Safety and precautions in welding. • Formation of weld bead by SMAW on mild steel flat. • Formation of weld bead by oxy-fuel welding on mild steel flat. • Introduction to sheet Metal works. • Tools and Machines used in sheet metal works. • Concept of development, marking out of metal sheets. • Cutting and joining of metal sheets. • Safety precautions, General warning needed in the shop floor. **Black smithy & Foundry -- 3X3= 9hrs.** • Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels. • Safety and precautions in blacksmithy. • Making of bars of different cross-sections. • Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology. • Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing.

	• DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree

	Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive.

	• Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS**

	• Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					
Course Outcomes	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.						

Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
	Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10thed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) /	Total Number of contact hours				Credit
			Lecture	Tutorial	Practical	Total	

		Electives (PEL)	(L)	(T)	(P)	Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic knowledge of computer.	CT+MT+EA
Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]

Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium						

	1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons 1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:**

	classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	<u>Text Books</u>: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. <u>Reference Books</u>: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University.

	4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.
• CO4: introduce the basic concept of single-phase transformer.
• CO5: analyze the transient phenomena in electrical circuits with DC</td></tr>
</table>

Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

CURRICULUM AND SYLLABUS FOR DUAL DEGREE PROGRAM IN BIOTECHNOLOGY

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody

	c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>XXC01</td><td>The Constitution of India and Civic Norms</td><td>PCR</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India.
CO2: Aware of the fundamental rights and duties as a citizen of the country.
CO3: Enable to know the civic norms to be followed according to the Indian constitution</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">1. Historical background of the Making of Indian Constitution (1 Hour)
2. Preamble and the Philosophical Values of the Constitution (1 Hour)
3. Brief Overview of Salient Features of Indian Constitution (1 Hour)
4. Parts I & II: Territoriality and Citizenship (1 Hour)
5. Part III: Fundamental Rights (2 Hours)
6. Part IV: Directive Principles of State Policy (1 Hour)
7. Part IVA: Fundamental Duties (1 Hour)
8. Union Government: President, Prime Minister and Council of Ministers (2 Hours)
9. Parliament: Council of States and House of the People (1 Hour)
10. State Government: Governor, Chief Mister and Council of Ministers (1 Hour)
11. State Legislature: Legislative Assemblies and Legislative Councils (1 Hour)
12. Indian Judiciary: Supreme Court and High Courts (1 Hour)
13. Centre-State Relations (1 Hour)
14. Reservation Policy, Language Policy and Constitution Amendment (1 Hour)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="6">Primary Readings:
1) P. M. Bakshi, The Constitution of India, 18th ed. (2022)
2) Durga Das Basu, Introduction to the Constitution of India, 25th ed. (2021)
3) J.C. Johari, Indian Government and Politics, Vol. II, (2012)
Secondary Readings:
Granville Austin, The Indian Constitution: Cornerstone of a Nation (1966; paperback ed. 1999); Granville Austin, Working a Democratic Constitution: The Indian Experience (1999; paperback ed. 2003).</td></tr>
</table>

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
</table>

XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)... Engineering Drawing and Graphics – K Venugopal 2)... AutoCAD — George Omura 3)... Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union						

	• CO4: Application of C-programming to solve various real time problems
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output						

	signals.
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end					

	assessment (EA))
None	CT+EA

Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: understand the principle of superposition. • CO2: understand the principle of maximum power transfer • CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: understand the calibration of energy meter. • CO5: understand open circuit and short circuit test of single-phase transformer. • CO6: analyze RLC series and parallel circuits • CO7: understand three phase connections. • C08: understand determination of B-H curve
Topics Covered	**List of Experiments:** 1. To verify Superposition and Thevenin's Theorem. 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit 9. Determination of B-H Curve for magnetic material
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru (Author), J M Chuma (Author), H U Ezea (Author) 2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through.						

	• Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice.

	TABLE TENNIS • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service. • Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

THIRD SEMESTER

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	MATHEMATICS-III	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of topics included in MAC01 & MAC02.		CT+MT+EA					
Course Outcomes	• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. • CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. • CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. • CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.						
Topics Covered	**Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14] **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14] **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17]						

Topics Covered	**Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	Suggested Text Books: 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar&R.K.Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig Suggested Reference Books: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2		2			2	2	3
CO2	1	2	1	1			3		2	1		3
CO3	3			2		1	2		2			3
CO4	3	3	3	2			1	2	1		2	3

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC331	PROCESS CALCULATIONS AND THERMODYNAMICS	PEL	3	0	0	3	3
Mathematics I and Mathematics II		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	● CO1: To develop the concept of dimension and unit conversion to check dimensional consistency of balanced equation ● CO2: Learn basic laws about the behavior of gases, liquids and solids and some basic mathematical tools. ● CO3: To Establish mathematical methodologies for the computation of material balances and energy balances with and without chemical reaction ● CO4: To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries. ● CO5: To analyze and interpret data, to identify, formulate, and solve engineering problems.
Topics Covered	Module - I (10 hrs) ● Significance of Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis Mathematical Requisites: Use of log-log and semi-log graph paper, Triangular Diagram. ● Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another. ● Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial volume, Dalton's law and Amagat's law and Numerical problems on their applications. ● Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications. ● Ideal & non-ideal solutions, Raoult's law, Henry's law and their applications in numerical problems. Module – II (10 hrs) ● Material Balances with and without chemical reaction: Material balances in crystallizers, gas - liquid absorbers, evaporators, distillation plant. Systems with recycle,drying, extraction. ● Energy Balance: Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, liquids and gases. Heat of fusion and vaporization ● Enthalpy calculation for systems with Chemical Reaction, Thermo-chemistry, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Adiabatic Flame Temperature, Theoretical Flame Temperature.

Topics Covered	Module – III (10hrs) ● Scope of thermodynamics, Terminology and fundamental concepts. Microscopic and macroscopic view. State and path functions, thermodynamics processes, Zeroth and First law of thermodynamics: Applications of first law to close and open system.Limitations of first law, Heat pump, heat engine, Second law of thermodynamics: Reversibility and irreversibility, Carnot cycle, concept and estimation of entropy, third law of thermodynamics, Clausiusinequality,Gibb's and Helmholtz free energy. Module – IV (10 hrs) ● PVT behavior of pure substance, Equations of state for ideal and real gases, cubic andvirial equation of state, problems, Compressibility factor,thermodynamic properties of pure substances. ● Refrigeration of gases: Refrigerator, Co-efficient of performance, capacity of refrigerator, Vapour compressioncycle, Choice of refrigerants.
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Process Calculations, D.C. Sikdar, HI Learning Private Limited, 2013 2. Stoichiometry and Process Calculations, K. V. Narayanan, B. Lakshmikutty, PHI Learning (2017) 3. Stoichiometry, Bhatt and Vora, Tata McGraw Hill Companies. 4. Introduction to Chemical Engineering Thermodynamics, GopinathHalder, Prentice-Hall Of India Pvt. Limited, 2009 5. A Textbook of Chemical Engineering Thermodynamics, Narayanan K.V, Prentice Hall India Learning Private Limited; 2nd edition ,2013 Suggested Reference Books: 1. Unit Operations–Chemical Process Principles – Part-I - Haugen, Wartson&Ragatz (CBS) 2. Basic Principles and Calculations in Chemical Engineering – Himmelblau ((Prentice Hall of India) 3. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill) 4. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 301	CELL BIOLOGY AND GENETICS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	CO1: To understand the basic organization of cells and organisms and the tools needed to study them CO2: To understand the basic processes of the cell machinery, cell-cell interaction and the eukaryotic cell cycle. CO3: To apply the knowledge of cell process regulation and cell cycle in understanding the use of a cell as a biological tool for manufacturing biomolecules. CO4: To learn the fundamentals of Genetics and its applications. CO5: To solve problems associated with genetic diseases and their transmission from one generation to the next
Topics Covered	**Classical Genetics:** Mendelian inheritance; Euploidy and aneuploidy (4) Genetic interactions (2) **Molecular Genetics**-Split and Overlapping genes; Transposons &Retrotransposons; Mutation (6) DNA Repair and human diseases (4) Recombination (2) **Internal Organization of the cell**: Cells as experimental models, Cells and cellular organelles, Tools of cell biology- Microscopy and cell Architecture, Purification of cells, Membrane structure, Membrane Transport of small molecules and electrical properties of membranes (8) **Cytoskeleton and cell movement:** Structure and organization of actin filaments, Actin myosin and cell movement, intermediate filaments, microtubules, microtubule motors and movements, cell-cell interactions (6) **Cell signalling** Signaling molecules and their receptors, function of cell surface receptors, pathways of intracellular signal transduction, signal transduction and the cytoskeleton, signalling in development and differentiation (6) **Cell cycle and cancer** Eukaryotic cell cycle, meiosis and fertilization, stem cells, Development and causes of cancer, oncogenes, tumor suppressor genes (4)
Text Books, and/or reference material	Suggested Text Books: 1. Molecular Biology of Cell by Albert et.al. John Wiley & Sons 2. The Cell by Cooper. ASM Press 3. M.W.Strickberger: Genetics, Pearson. 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, Suggested Reference books: 1. Cell and Molecular Biology by Karp. John Wiley & Sons1992 2. Stratchan& Read: Human Molecular Genetics 3. David Freifelder: Microbial Genetics, Jones and Bartlett Publisher Inc. 1987 4. In Introduction to genetic analysis, Griffiths, Miller, Suzuki, Lewontin and a. Gelbart, Freeman and Company

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 302	MICROBIOLOGY AND BIOPROCESS TECHNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01 (LIFE SCIENCE)		CT+MT+EA					

Course Outcomes	CO1: To develop knowledge on different types of microorganisms including viruses and microscopy for the visualization of microorganisms, their characteristic features as well as internal and external structures and their functions. CO2: To impart an understanding on microbial classification and taxonomy, microbial community and interactions, microbial nutrition, nutritional types, growth media, growthin different systems, and control of microorganisms using various physical and chemical treatments including antimicrobial drugs. CO3: To develop knowledge on microbial metabolism, energy transduction mechanisms, and microbial genetics CO4: To acquire experimental know how of microbial production of various industrial products such as alcohol, antibiotics, amino acids, vitamins exopolysaccharides, enzymes, etc. from industrial strains. CO5: To illustrate the upstream and downstream processing for product recovery and purification. CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**PART A: Microbiology** **Introduction to microbiology:** History and scope of microbiology, major contribution and events in microbiology, different types of microorganisms – characteristic features, microbes and diseases, microbes in human welfare.**[2]** **Microbial structures:** Different types of microscopy, preparation and staining of specimens, microbial shape, size, arrangements, overview of procaryotic and eucaryotic cell – internal and external structures, cytoplasmic matrix, nucleoid, plasmids, ribosomes, flagella, pilli, fimbrie, spores, bacterial and archaebacterial cell walls and cell membranes, Viruses – types, structures, multiplications **[4]** **Microbial classification and taxonomy:** Domains of life, classification, taxonomic ranks, techniques for determining microbial taxonomy and phylogeny, prokaryotic phylogeny and diversity, microbial community and interactions – Mutualism, Cooperation, Commensalism, Predation, Parasitism, Amenalism, Competition. Normal microbiota of human body. **[3]**

Topics Covered	**Microbial nutrition, growth and control:** Common nutrient requirements, nutritional types, uptake of nutrients by cell, culture media, pure culture, microbial growth – batch culture and continuous culture, growth curve, measurement of growth, influence of environmental factors on growth, control of microorganisms by physical and chemical agents, Antimicrobial drugs – general characteristics, narrow-spectrum and broad-spectrum drugs, inhibitors of cell wall synthesis, nucleic acid synthesis and protein synthesis, metabolic antagonists, Drug resistance. [**5]** **Microbial metabolism:** Energy release and conservation, chemoorganotrophic fueling processes, aerobic respiration, glycolysis, TCA cycle, electron transport and oxidative phosphorylation, anaerobic respiration - nitrate and sulphate reduction, fermentations, chemolithotrophy, phototrophy [3**]** **Microbial genetics:** Conjugation, Transduction, Transformation [**4]** **PART B: BIOPROCESS Technology** A) Introduction to Fermentation Technology: Microbial Culture systems; Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; The development of Inoculum for Industrial fermentations; Starter Cultures; Downstream Processing and fermentation economics. ………………………….. **[4]** B) Commercial Strain Development & Microbial Processes: Sources of industrial cultures and maintenance. Alcoholic fermentation: Production of Industrial Alcohol – Fermentation mechanism. Recent developments, brewing and malting, manufacture of wine and other distilled liquors. Cellular control regulating production of microbial metabolites – Primary and Secondary metabolite – Induced mutation technique – Analogue resistant mutant – Catabolic derepressed mutants – Genetically engineered strain – Protoplast fusion technique. Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. **[5]** C) Microbial production of nucleosides and nucleotides: i) Introduction ii) Classification of methods for production of 5’ IMP and 5’GMP iii) Production of 5’IMP and 5’GMP by fermentation. ……………………………………………………**[3]** D) Microbial production of Vitamins: 1) Vitamin B12 - Organisms used, production method- process, recovery and assay. 2) Vitamin C - Organisms used, production method, process, recovery and assay. **[3]** E) Lectures Microbial Production of Antibiotics : Organism used, production process and recovery of- 1) Bacitracin & 2) Chloramphenicol [**2**] F) Lectures Microbial Production of acids, viz., citric, lactic, Acetic acid, vinegar and gluconic acid. Mechanism of each fermentation, their uses. its spoilage and prevention **[2]** G) Production of Amino acids (Lysine and glutamic acid) and Antibiotics (Pencillin, Streptomycin and Tetracyclines) and its new Developments ……………**[2]**

Text Books, and/or reference material	Suggested Text Books: 1. Prescott, Harley and Klein's Microbiology – McGraw Hill 2. Microbiology by Pelczar, Chan and Krieg, Tata Mc Graw Hill 3. L.E. Casida. Jr, Industrial Microbiology, New Age International Publisher 4. W. Crueger, AnneliseCrueger, Biotechnology: A Textbook of Industrial Microbiology, Pnima Publishing Corporation 5. Fermentation microbiology and biotechnology. Ed. E.M.T. El-Mansi , C.F.A. Bryce, B. Dahhou, S. Sanchez, A.L. Demain, A.R. Allman. 3rd ed. Taylor and Francis. Suggested Reference Books: 1. Microbiology by Tortora, Funke and Case 2. Brock Biology of Microorganisms 3. General Microbiology by Hans G Schlegel, Cambridge 4. Atkinson. B and Marituna. F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ.Ltd.4 5. James E Bailey, David F., Ollis, Biochemical engineering fundamentals, second edition. McGraw Hill

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC303	BIOCHEMISTRY AND ENZYME TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	**CO1:** To understand the principles of bioenergetics and to correlate them with the metabolic pathway. **CO2:** To impart an understanding on the fates of macromolecules during metabolism. **CO3:** To provide an understanding on the importance and synthesis of energy currency molecule, ATP. **CO4:** To interpret the regulation in the metabolic pathway and to study the role of hormones in the metabolic pathway. **CO 5:** To understand mechanism and kinetics of enzyme action and their regulation for application of enzymes in living system and for industrial purpose.

Topics Covered	**Module 1** **(3+2)5** Biomolecules, Vitamins Principles of Bioenergetics **Module 2** **Carbohydrate and its metabolism** **5** **Carbohydrate Biosynthesis** - Gluconeogenesis, Biosynthesis of glycogen, starch, Sucrose , Photosynthetic Carbohydrate Synthesis, **Glycolysis and catabolism of hexoses -** Glycolysis, pentose phosphate pathway of glucose oxidation, Citric acid cycle, regulation of citric acid cycle, glyoxylate cycle . Role of hormones in metabolism **Oxidative Phosphorylation and Photo Phosphorylation** - Oxidative Phosphorylation, Regulation of Oxidative Phosphorylation, Photosynthesis **Module 3** **3** **Lipid and its metabolism** O**xidation of Fatty acids** - Transport of fatty acid, beta-oxidation, Ketone bodies **Lipid Biosynthesis** - Biosynthesis of fatty acids **Module 4** **3** **Protein and its metabolism** **Amino acid oxidation and production of Urea** - Metabolic fates of amino groups, Nitrogen excretion and the urea cycle, Pathways of amino acid degradation Nitrogen metabolism, Biosynthesis of amino acids, **Module 5** **2** **Nucleic acid and its metabolism** Biosynthesis and degradation of Nucleotides **Module 6** **12** **Enzyme Technology and Vitamins** **Enzymes:**Nomenclature of enzymes, Enzyme kinetics, Mechanism of enzymatic, Catalysis, Active site, Activators and inhibitors, Coenzymes, Isoenzymes, Michaelis-Menten equation, Km and Vmax value, Regulation of enzyme activity (single-substrate and multi-substrate reactions). Vitamin's as coenzyme **Production of enzymes and immobilisation** : Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis. Enzyme immobilization: Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme. Engineering of Enzymes **Application of enzyme** in leather industry, detergent industry, dairy industry; Lignocellulose degrading enzymes.
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Biochemistry by LubertStryer. W. H. Freeman & Company, NY 2. Biochemistry by Lehninger. McMillan publishers <u>Suggested Reference Books:</u> 1. Biochemistry, Voet&Voet 2. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press 3. Enzyme technology by Chaplin and Bucke. Cambridge Univerity Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS351	MICROBIOLOGY LABORATORY	PEL	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To learn and become familiar with types of culture media, preparations of culture media, sterilization procedures, types of equipments. CO2: To understand the concept of sterility, working principles and applications of instruments: autoclaving, laminar air flow hood etc. CO3:To learn about the isolation and maintenance process of bacterial cultures. CO4: To apply the understanding of the cultural and morphological characteristics of microorganisms grown in pure culture.Applications in Antimicrobial effect and CO5: To interpret microbial growth phases its kinetics specific growth rate.to determine the effects of chemicals on bacteria and to understand the quality of water.
Topics Covered	**Microbial culture media preparation:** Basic concepts of nutrition materials in media, classes of culture media, how to prepare growth media. **The control of microbial growth :** To study the methods of sterilization: autoclaving, laminar air flow hood, irradiation, filtrations, chemical and gas. **Isolation of microorganisms from an environment of choice :** To demonstrate the ubiquity and diversity of microbes in the environment, samples from immediate areas of the environment will be obtained and cultured and dilution methods. **Isolation and Maintenance of pure cultures :** To study the different techniques of isolation and maintenance of pure cultures: subculturing, streak plate method, pour plate method, spread plate method. **Bacterial morphology and staining :** To study the physical properties and differentiation of microorganisms with the help of different staining procedures: differential and structural staining. Techniques of Gram staining, endospores staining, microscopic study.

	Estimation of coliform bacteria: To study the estimation of coliform bacteria in water by MPN (most probable number) test. **Study of bacterial growth:** To study the growth pattern of bacteria, specific growth rate calculation, different growth phases of bacteria. **Antimicrobial activity study:** To determine the antibiotic susceptibility via sensitivity disk methods, calculation of zone of inhibition.
Text Books, and/or reference material	Suggested Text Books: 1. Benson HJ. 2002. Microbiological applications: a laboratory manual in general microbiology: McGraw-Hill New York, NY. 2. Harley JP. 2004. Laboratory exercises in microbiology: McGraw-Hill Science/Engineering/Math Suggested Reference Books: 1. Brown AE. 2009. Benson's Microbiological Applications: Laboratory Manual in General Microbiology, Short Version: McGraw Hill 2. Madigan MT, Martinko JM, Dunlap PV, Clark DP. 2012. Brock biology of microorganisms: Pearson/Benjamin Cummings. 3. Pollack RA. 2004. Laboratory exercises in microbiology, 3e. Recherche 67: 02

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS352	BIOCHEMISTRY LABOARTORY	PCR		0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To design , analyze and solve problems and learn to plot graph and interpret data CO2: To develop skills to perform experiments and have hands on training. CO3: To apply the results and data to solve problems in daily activities and industry.						

Topics Covered	1. To prepare Tris-HCl Buffer with a specific pH (eg. pH 8.8) 2. Qualitative and quantitative estimation of carbohydrates 3. Qualitative and quantitative estimation of aminoacids and determination of the unknown concentration of protein concentration by plotting a standard curve of BSA using Bradford reagent 4. Ammonium sulphate precipitation and dialysis for a protein 5. Separation and Identification of Amino acids by Paper Chromatography and Thin Layer Chromatography 6. Analysis of Protein purity and determination of molecular weight of pure protein by SDS PAGE and Coomassie Brilliant blue staining of proteins on SDS gel 7. Extraction of Enzyme Tyrosinase from commercially available mushrooms and Assay of Enzyme Tyrosinase with determination of specific activity of Enzyme Tyrosinase 8. Effect of substrate concentration on the activity of Enzyme Tyrosinase and determination of MichelesMenton parameters of Enzyme Tyrosinase 9. Effect of inhibitor concentration on the activity of Enzyme Tyrosinase
Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry by David T Plummer Suggested Reference Books: 2. Biochemistry by Voet and Voet

FOURTH SEMESTER

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC401</td><td>MOLECULAR BIOLOGY AND rDNA TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC01 Life Science
BTC301 Cell Biology and Genetics
BTC303 Biochemistry and Enzyme Technology</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will acquire basic understanding of molecular biology topics: nucleic acid structure and chemistry; organization of genome in chromosomes; regulation of replication, transcription, translation and DNA repair.
CO2: Students will acquire knowledge of recombinant DNA techniques on: nucleic acid amplification and gene cloning; manipulation of DNA sequences; preparation and screening of nucleic acid libraries; gene silencing; analysis of variations in genome sequence.
CO3: Students will be proficient in applying basic understanding of molecular biology topics in analyzing and solving problems related to recombinant DNA technology.
CO4: Students will be able to design strategies to solve problems related to recombinant DNA technology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Nucleic acid structure: Nucleotides and nucleic acids, DNA structure, different forms of DNA, unusual DNA structure, different types of RNA, RNA structure. [3]
2. Nucleic acid chemistry: Denaturation and renaturation, hybridization, nonenzymatic transformation (Mutation) – spontaneous and induced, point mutation - transition, transversion, mutation involving more than one base pairs, insertion, deletion, frame shift mutation, forward and back mutation, null mutation, Loss-of-function and gain-of-function mutation, silent mutation, DNA sequencing. [4]
3. Chromosome organization: Chromosomal elements – genes and intergenic regions, regulatory sequences; DNA supercoiling, linking number, Chromosome structure: Histones, Non-histones, Nucleosome, Chromatin. Chromosome structure in prokaryotes & eukaryotes. [4]</td></tr>
</table>

	4. DNA replication and repair: Central dogma, DNA replication in prokaryots and eukaryots – set of fundamental rules, DNA polymerases, proteins and enzymes involved in replication, process, accuracy. [4] 5. Transcription and post-transcriptional processing: DNA-dependent RNA synthesis in prokaryotes and eukaryotes, RNA polymerases, transcription process, termination, selective inhibition, RNA processing – capping, splicing of introns, differential RNA processing; RNA-dependent synthesis of RNA and DNA. [4] 6. Protein synthesis – translation: Genetic code, ribosome, transfer RNA, protein biosynthesis stages – attachment of amino acid to specific tRNA, initiation, elongation, termination, folding and processing; inhibition of protein synthesis. [4] 7. DNA repair: DNA repair – multiple repair systems. [3] 8. Regulation of gene expression: Regulation of gene expression in bacteria - operon concept; Regulation of gene expression in eukaryotes, hormonal control of gene expression in eukaryotes. [3] 9. Introduction to recombinant DNA and Gene Cloning Tools of recombinant DNA: Vectors; plasmid, bacteriophage viral vectors, cosmids, yeast artificial chromosome. Expression vectors, and selection of suitable Host. [5] 10. Restriction endonucleases and other enzymes use and mechanism of action and analysis, Genomic DNA and cDNA library preparation. Strategies for engineered vectors use and regulation for enhanced gene expression and purification. [5] 11. Screening and selection of clone with desired gene and protein of interest: Colony and plaque hybridization. antibody based assay, Protein activity. Application of gene cloning and DNA Analysis. [3] 12. Molecular probes: Preparation of molecular probes DNA probes, RNA probes, radioactive labeling, Non-radioactive labeling, use of molecular probes in DNA fingerprinting. Southern blotting, Northern blotting, Western blotting, In-situ hybridization. [4] 13. MOLECULAR TECHNIQES: Polymerase chain reaction, different types and their use. Antisense RNA technology, Site directed mutagenesis, Use of RFLP, SNP and Microarray. [4]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Gene IX by B. Lewin, Pearson 2. Molecular biology of the cell by Albertset. al., Garland science <u>Suggested Reference Books:</u> 1. Molecular Biology of the Gene, 7th edition 2013. Watson et. al. Published by Pearson. 2. Cell and molecular Biology, Concepts and experiments Gerald Karp, John Wiley and Sons. 3. The Cell - A molecular approach, GM Cooper ASM Press 4. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC431</td><td>UNIT OPERATIONS OF CHEMICAL ENGINEERING I</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Mathematics, Unit Operations</td><td colspan="7">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="7">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CA1:To Understand fundamentals of fluid dynamics and mechanics
• CA2:Understanding the fundamentals of heat transfer operations
• CA3:To learn design of heat transfer equipment and calculations
• CA4:To develop knowledge of different mechanical operations and their applications
• CA5:To solve related problems of different difficulty levels through tutorials</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Module - I (14 hrs)
Fundamental Concepts: Definition of Fluid, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; flow visualization – streamline, path line, streak line, viscosity; Newtonian fluid; Non-Newtonian fluid; Reynold’s number—its significance, laminar, transition and turbulent flows.
Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices– manometer, U-tube, inclined tube. Introduction to rotational and irrotational flow. Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli’s equation–kinetic energy correction factor.
Fluid moving machines: Introduction; Basic classification of pumps: Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); Peristaltic pump; Pump specification; Basic characteristics curves for centrifugal pumps
Module – II (14 hrs)
Basic modes of heat transfer; Heat transfer by conduction: One dimensional steady state heat conduction, Fourier’s Law, Thermal conductivity, Compound resistance in series; Steady state heat transfer analysis through extended surface; Unsteady state heat conduction with and without heat generation, Concept of thermal diffusivity; Concept of heat transfer coefficient in convective-conductive system, Critical thickness of insulation.</td></tr>
</table>

	Heat transfer by convection: Convection heat transfer mechanism; Forced convection in systems of simple geometrics (plate, cylinder etc.), Thermal boundary layer; Co-relation for heat transfer coefficient: internal flow & external flow, Momentum & heat transfer analogies. Evaporation: Classification; Capacity, Steam economy; Boiling point elevation (Duhring rule); Material and energy balance of single effect evaporator; Introduction to multiple effect evaporator: Forward feed, Backward feed, Mixed feed, Parallel feed Module – III (12 hrs) Particulate solids: Characterization of solid particles, particle shape, particle size, mixed particle sizes and size analysis, specific surface of mixture, average particle size. Screen analysis: Type of screens, ideal screen, real screen, screen effective ness, differential and cumulative analysis, screen capacity. Screening equipment: stationary screens and grizzlies, gyrating screens, vibrating screens and other industrial screens like trammels etc. Comminution of solids (Size Reduction): Factors affecting commnution, comminution laws: Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption.
Text Books, and/or reference material	Suggested Text Books: 1. A Textbook of Fluid Mechanics And Hydraulic Machines, R.K. Bansal, Laxmi Publications; Tenth edition, 2018) 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. 3. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 4. Mechanical Operations for Chemical Engineers, C.M. Narayanan and B.C. Bhattacharya, KHANNA PUBLISHERS, 1990 Suggested Reference Books: 1. Process Heat Transfer: D. Q. Kern, MGH, 1983 2. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977 3. Principles of Unit Operations by Alan S Foust, L.A. Wenzel, C.W. Clump, L. Maus, and L.B.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 402	IMMUNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01		CT+MT+EA					

Course Outcomes	CO1: To understand the role of the components of the immune system and its classification CO2: To understand the role of the immune cells and their immunological response in the context of human diseases including infectious diseases, autoimmunity, and cancer. CO3: To learn the fundamentals and principles of immunological techniques and their application. CO4: To understand methods of generations of Polyclonal and Monoclonal Antibody and the use of custom made genetically engineered antibodies. CO5: To solve problems associated with drugs and their toxic response based on the knowledge of immunological response.
Topics Covered	**Immunology-** fundamental concepts and anatomy of the immune system Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing (6) **Immune responses generated by B and T lymphocytes** Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; (2) Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily (3) Kinetics of Active and Passive Immunity, Basis of self –non-self discrimination; (4) B cell maturation, activation and differentiation; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses (6) Hypersensitivity, Antibody Dependent Cell Cytotoxicity; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation Hapten-carrier system. Complement system. (4) **Antigen – Antibody Interaction dependent Techniques** Precipitation, Agglutination; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, Immuno-electron microscopy and Immuno flourescence techniques (6) **Clinical Immunology:** Preparation and clinical uses of Monoclonal and Polyclonal antibody. (3) Transplantation; Autoimmunity; (5) Vaccination: Principles and development of vaccines against different diseases. (3)
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications. 1999 <u>Suggested Reference Books:</u> 1. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002. 2. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999. 3. Goding, Monoclonal antibodies, Academic Press. 1985.

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC431</td><td>PROGRAMMING AND DATA STRUCTURE</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Knowledge of Programming Language</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Understanding of the fundamental concepts of data, data types and abstract data types.
● CO2: Implementation of different abstract data types using different data structures.
● CO3: Apply different types of data structures to implement different solutions to problems.
● CO4: Analysis of the suitability/compatibility of different data structures based on the types of applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1) Introduction: Basic terminology, elementary data organization, structure operations, algorithm, complexity and time-space trade-off. [2]
2) Arrays: Array definition, representation and analysis, single and multidimensional arrays, address calculation, application of arrays, character string in c, character string operation, array as parameters, ordered list, sparse matrices and vectors. [4]
3) Stacks: Array representation and implementation of stack, operations on stacks: push AND pop, array representation of stack, linked representation of stack, operations associated with stacks, application of stack: conversion of infix to prefix and postfix expressions, evaluation of postfix expression using stack. [5]
4) Queues: Array and linked representation and implementation of queues, operations on queue: create, add, delete, full and empty, circular queues, d-queues and priority queues. [4]
5) Linked list: Representation and implementation of singly linked lists, two-way header list, traversing and searching of linked list, overflow and underflow, insertion and deletion to/from linked lists, insertion and deletion algorithms, doubly linked list, linked list in array, polynomial representation and addition, generalized linked list, garbage collection and compaction. [7]</td></tr>
</table>

	6) Trees: Basic terminology, binary trees, binary tree representation, algebraic expressions, complete binary tree, extended binary trees, array and linked representation of binary trees, traversing binary trees, threaded binary trees, traversing threaded binary trees. [7] 7) Searching: Sequential search, binary search. [2] 8) Sorting: Insertion Sort, Selection Sort, Bubble Sort, Radix Sort, Quick Sort, Merge Sort and Heap Sort. [8] 9) Binary Search Trees: Binary Search Tree (BST), Insertion, Deletion and Search Operations in BST. [5] 10) Height Balance Tree: Introduction to Height Balance Tree, Insertion, Deletion and Search Operations in Height Balance Tree. [5] 11) Graphs: Terminology and representations, graphs and multi-graphs, directed graphs, sequential representations of graphs, adjacency matrices, traversal, connected component and spanning trees, minimum cost spanning trees. [7]
Text Books, and/or reference material	Suggested Text Books: 1. Horowitz and Sahani, "Fundamentals of data Structures", Galgotia Publication Pvt. Ltd., New Delhi. 2. R. Kruse etal, "Data Structures and Program Design in C", Pearson Education Asia, Delhi-2002 3. A. M. Tanenbaum, "Data Structures using C & C++", Prentice-Hall of India Pvt. Ltd., New Delhi Suggested Reference Books: 1. Bruno R Preiss, "Data Structures and Algorithms with Object Oriented Design Pattern in C++", Jhon Wiley & Sons, Inc. 2. 6. Adam Drozdek, "Data Structures and Algorithms in C++", Thomson Asia Pvt. Ltd.(Singapore)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO 441	FOOD BIOTECHNOLOGY	PER/OER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01		CT+MT+EA					

Course Outcomes	CO1: To quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation and increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.
Topics Covered	**Food Microbiology: [8]** Microorganism in food, Intrinsic and extrinsic parameters of food**,** rapid methods for identification of microorganism in food, Food borne illness, Biosensors –use and application **Food preservation [8]** Pasteurization, sterilization, Canning, thermal process of food with numericals, Irradiation, Dehydration, low temperature , use of preservatives **Food fermentation [10]** **Role of lactic acid bacteria in fermentation and strain improvement**, Fermentation of meat, fish, vegetables, beverages, dairy product, non-beverage product , use of genetic engineering techniques for improved quality product**.** **Genetically modified food [8]** Fruit ripening, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Ethical and regulatory issues **Biotechnology in relation to food product [4]** Antioxidant, nutraceutical, **Food safety [6]** Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series, detection of toxin, heavy metal , pesticide and herbicides
Text Books, and/or reference material	<u>Suggested Text Books:</u> Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater <u>Suggested Reference Books:</u> Fundamentals of Food Biotechnology by Lee

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS451	CELL BIOLOGY AND GENETICS LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Cell Biology and Genetics (BTC301)	CT+EA

Course Outcomes	CO1: To design, analyze and solve problems related to cell biology and Molecular genetics and interpretation of data obtained by the lab experiments. CO2: To develop skills to perform experiments related to cell biology and Molecular genetics and have hands on training on the related area. CO3: To learn to interpret data, draw conclusion and develop trouble shooting skills.
Topics Covered	1. Isolation of chromosomal DNA from mammalian cells. 2. Genotyping PCR of a genetically modified cell. 3. Isolation of mRNA and RT-PCR to determine the level of transcription of the gene. 4. Studying to detect variations like single nucleotide polymorphism. 5. Studying bacterial conjugation. 6. To examine the morphology of cells 7. Identification of cellular organelles by staining method 8. Cell proliferation assay 9. Cell adhesion assay 10. Cell migration assay
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: ● Molecular Biology of Cell by Albert et.al. John Wiley & Sons ● The Cell by Cooper. ASM Press ● M.W.Strickberger: Genetics, Pearson.

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS481	UNIT OPERATIONS OF CHEMICAL ENGINEERING LABORATORY I	PCR	0	0	3	3	3

CHC431: Unit operations of chemical engineering-I.	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	CO1: To record observations systematically and arrive at required results based on experiments conducted CO2. Understand the principles, laws and mechanism of different comminuting methods like sieve analysis crushers, and grinders, ball mill CO3. Acquire the knowledge of a cyclone separator and its efficiency CO4. Acquire the knowledge of different flow regime measuring instruments. CO5. Study and design different flow measuring instruments.
Topics Covered	• To find out the reduction ratio and capacity and to verify the laws of crushing by Jaw Crusher. • To determine the optimum speed for maximum new surface area created for the given feed size and also determines the critical speed of the ball mill. • Demonstration of the operation of a cyclone separator and determination of its overall efficiency • Experiments on Reynolds Apparatus for determination of flow regime and construction of Fanning friction factor vs. Reynolds No. plot • Determination of co efficient of Discharge for Orifice meter and Discharge for Venturi meter. • Determination of co-efficient of Pitot tube and construction of velocity profile across the cross section of pipe. • Experiment to prove Bernoulli's equation for fluid flow • To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions and to find out screen efficiency
Text Books, and/or reference material	Suggested Text Books: 1. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. Suggested Reference Books: 1. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977 2. Principles of Unit Operations by Alan S Foust, L.A. Wenzel, C.W. Clump, L. Maus, and L.B.

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS481	PROGRAMMING AND DATA STRUCTURE LABORATORY	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Knowledge of Programming Language		CT+MT+EA					

Course Outcomes	• CO1: Choose appropriate data structures for representation and manipulation of the data for the given problems. • CO2: Handle operations like search, insertion, deletion, traversing and sorting on various data structures. • CO3: Have knowledge on the applications of linear and non-linear data structures for real life problems. • CO4: Able to store and manipulate data in an efficient manner. • CO5: Able to implement stack, queue, binary tree, etc. using arrays and linked lists. • CO6: Able to apply the concepts learnt through thiscourse in various domains like DBMS and compiler.
Topics Covered	**Linked List** • Implementations of Linked Lists menu driven program • Implementation of different operations on linked list – copy, concatenate, split, reverse, count no. of nodes etc. • Representation of Sparse matrix using multilinked structure. Implementation of sparse matrix addition and multiplication • Implementation of polynomial operations (addition, subtraction) using Linked List • Implementations of Doubly Linked List **Stack** • Implementations of stack menu driven program using array and linked list • Implementation of multi-stack in one array • Implementations of Infix to Postfix Transformation and its evaluation program • Implementations of Infix to Prefix Transformation and its evaluation program **Queue** • Implementations of double ended queue menu driven program using array and linked list • Implementations of circular queue menu driven program using array and linked list • Implementation of Priority queue program using array **Tree** • Implementations of Binary Tree menu driven program • Implementation of Binary Tree Traversal program • Implementations of BST program • Implementation of various operations on tree like – copying tree, mirroring a tree, counting the number of nodes in the tree, counting only leaf nodes in the tree **Sorting** • Implementations Insertion sort, Selection sort, Bubble sort and Quick sort menu driven program **Searching** 12) Implementations of Sequential and Binary Search menu driven program

Text Books, and/or reference material	Suggested Text Books: 1. Horowitz and Sahani, “Fundamentals of data Structures”, Galgotia Publication Pvt. Ltd., New Delhi. 2. R. Kruse etal, “Data Structures and Program Design in C”, Pearson Education Asia, Delhi-2002 3. A. M. Tanenbaum, “Data Structures using C & C++”, Prentice-Hall of India Pvt. Ltd., New Delhi Suggested Reference Books: 1. Bruno R Preiss, “Data Structures and Algorithms with Object Oriented Design Pattern in C++”, Jhon Wiley & Sons, Inc. 2. Adam Drozdek, “Data Structures and Algorithms in C++”, Thomson Asia Pvt. Ltd.(Singapore)

FIFTH SEMESTER

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 501	BIOCHEMICAL REACTION ENGINEERING AND BIOREACTOR DESIGN	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	CO1 – To gain knowledge about Chemical and Biochemical processes, order of reactions, effect of various parameters on rate constant of a reaction C02- To study about different reactions in batch reactors, kinetics of enzyme catalyzed reactions CO3- To acquire knowledge about different ideal and non-ideal reactors, reaction kinetics, microbial growth kinetics CO4- To learn about various types of Bioreactors, their design considerations and applications in the field of Biochemical Engineering CO5- To study about mass transfer in bioprocess systems, scale up, instrumentation and control, bioreactor considerations in plant and animal cell culture						
Topics Covered	Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction. [5] Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes.–derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive. [5] Fundamentals of homogeneous reactions for batch, plug flow and mixed flow reactors. [5] Concept of ideal and non ideal reactors, Residence time distribution, Models for non ideal reactors (Dispersion model, tanks-in-series model). [5]						

	Stoichiometry of cellular reactions. Microbial growth kinetics (Batch, continuous, fed batch). Monod model and other kinetic models. Growth kinetics with plasmid instability. [6] Bioreactor design: Packed bed bioreactor, Fluidized bed bioreactor, Bubble column bioreactor, Air lift bioreactor, Tower bioreactor. Hollow fiber bioreactor, Membrane bioreactor. [4] Design of fermenter. Fermenter utilities – boiler and refrigeration system. [5] Immobilized cell bioreactor system. Mass transfer in bioprocess system. Two film theory, K_{la} determination. Scale up concepts. Bioreactor considerations for plant and animal cell culture [5] Bioprocess instrumentation and control. Computer controlled bioreactors. [2]
Text Books, and/or reference material	Suggested text books: 1. Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. 2. Bioprocess Engineering Principles – Pauline M Doran. Academic press 3. Chemical Reaction Engineering ,O Levenspiel, Wiley 4. Principles of Fermentation Technology, Stanbury and Whitaker, Pergamon press Suggested reference books: 1. Biochemical Engineering. Fundamentals, Bailey &Olis, McGraw-Hill 2. Biochemical Engineering, Humphrey and Aiba. Academic Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC502	CELL AND TISSUE CULTURE	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01 Life Science BTC301 Cell Biology and Genetics		CT+MT+EA					
Course Outcomes	**CO1:** Students will acquire knowledge on plant and animal cell and tissue growth conditions. **CO2:** Students will be acquainted with plant and animal cell and tissue culture techniques in laboratory and industry setups. **CO3:** Students will be proficient in applying basic understanding of plant and animal cell and tissue growth requirements in plant and animal tissue culture techniques.						

Topics Covered	1. Introductory history, plant & animal cell culture facilities laboratory organization, media & aseptic conditions. [2] 2. Plant growth hormones, Cell culture, cellular totipotency, somatic embryogenesis, anther, pollen and ovary cultures, protoplast culture. [6] 3. Haploid production, triploid production, in vitro pollination and fertilization, zygotic embryo culture, somatic hybridization and cybridization, genetic transformation, somaclonal and gametoclonal variant selection. [7] 4. Production of disease-free plants, clonal propagation. [3] 5. Industrial applications: secondary metabolite production, germplasm conservation. [3] 6. Animal Cell Culture: Historical Background. [1] 7. Importance of and progress in Animal Cell Culture Technology. [1] 8. Biology of Animal Cell; Cellular Interactions. [5] 9. Importance of Serum and Serum Free Media. [2] 10. Culturing and Sub-Culturing of Animal Cells. [3] 11. In Vitro Transformation of Animal Cells. [1] 12. Cell Differentiation & Cell Movement. [2] 13. Cloning of Animal Cells. [2] 14. Cell Line Preservation. [1] 15. Cell Line Characterization. [2] 16. Chromosome Spreading and Karyotype Analysis. [2] 17. Mycoplasma: Detection and Control. [1] 18. Monoclonal Antibody Production. [2] 19. Insect Cell Culture: An Overview. [2]
Text Books, and/or reference material	Suggested Text Books: 1. Razdan – Introduction to Plant Tissue Culture, 2nd edition, 2007, Oxford and IBH Publishing. 2. "Culture of AnimalCells: A manual of basic technique", 4 th Edition Author(s)/Editor(s): Freshney RI. Publisher: WIELY-LISS ISBN:0-471-34889-9. Suggested Reference Books: 1. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice, a revised edition, 2009, Elsevier. 2. Jha and Ghosh – Plant Tissue Culture: Basic and Applied, revised 2nd edition, 2016, Platinum Publishers.

Department of Biotechnology

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC503	BIOSEPARATION AND BIOCHEMICAL ANALYSIS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					

Basic Physics, Mathematics including basics of Differential & Integral Calculus, Basic concepts of Chemistry & Biochemistry	CT+MT+EA
Course Outcomes	CO1: To learn the concepts of separation including purification sequence and its monitoring and the properties of proteins underlying bioseparations. CO2: To learn techniques of biochemical analysis of biomolecules. CO3: To learn and analyze, mathematically wherever applicable, the various unit operations in bioseparation. CO4: To understand the design aspects of unit operations in bioseparation. CO5: To solve problems of bioseparations including industrial bioseparations.
Topics Covered	**Basic Concepts** **[3]** Basic concepts of Bio-separation Technology **Basic Analytical Tehniques:** **[10]** Introduction to Biomolecules, Buffers Estimation of carbohydrate, protein, and lipid, and enzyme assay Quantitation of DNA and RNA Methods of cell disintegration **Removal of Insolubles** **[9]** Flocculation and conditioning of broth. Filtration at constant pressure and at constant rate; equations for batch and continuous filtration, centrifugal and cross-flow filtration. Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications. **Techniques Involved in Separation Processes for Solutes** **[9]** Foam-fractionation; Solvent extraction, aqueous two-phase extraction, adsorption & desorption processes; Salt precipitation Membrane based separation processes:Micro-filtration, Dialysis, Reverse osmosis, Ultrafiltration and affinity ultrafiltration, concentration polarization, rejection, flux expression, membrane modules, dead-end and cross-flow modes. **Advanced Techniques for Bioseparation:** **[9]** Chromatography: paper chromatography, TLC, gel filtration, ion exchange, hydrophobic interaction chromatography, affinity chromatography, HPLC. Electrophoresis: Theory and application of Polyacrylamide and Agarose gel electrophoresis; 2D-Gel electrophoresis **Industrial Application with an example** **[2]**

Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Suggested Reference Books: 1. D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 2. Shuler & Kargi, Bio-process Engg. PHI 3. Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC531	UNIT OPERATIONS OF CHEMICAL ENGINEERING-II	PCR	3	1	0	4	4
CHC431: Unit operations of chemical engineering-I.		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• To learn different types of mass transfer phenomena • Understanding the fundamentals of mass transfer operations • To learn design parameters, their effects and calculations • To compare different types of mass transfer operations and their applications • To solve related problems of different difficulty levels through tutorials
Topics Covered	**Module I:** Principles of mass transfer: Introduction, diffusion, classification of diffusion, Inter-phase mass transfer. [8 hr] **Module II:** Evaporation: Introduction, types of evaporators, design calculation and processes [8 hr] **Module III:** Drying: Principles of drying, drying characteristics, methods, equipment. Humidification and Dehumidification: Definitions, adiabatic saturation temperature, wet bulb temperature, processes [8 hr] **Module IV:** Absorption: Principle, operation and design calculation [8 hr] **Module V:** Distillation: Flash distillation, differential distillation, fractionation and design calculations [8 hr] **Module VI:** Extraction and Adsorption: Principles and Operations. [8 hr]

Text Books, and/or reference material	Suggested Text Books: 1. B.K.Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Private Limited 2. N Anantharaman and K.M.M.S. Begum, Mass Transfer theory and practice. Prentice Hall India Private Limited 3. Robert E. Treybal, Mass Transfer Operations, McGraw Hill limited Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO540	MINERAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: To understand the nature and characteristics of different biogeochemical cycles and involvement important micro-organisms. • CO2: To learn the basic concepts of bioleaching and biobeneficiationalong with the microbiological aspects • CO3: To gain the detail knowledge bioleaching processes with examples. • CO4: To demonstrate and provide examples on how to use microbes for the environmental pollution control						
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8						

Text Books, and/or reference material	Suggested Text Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology , Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235 , 1983 Suggested Reference Books: 1. Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO541	INTRODUCTION TO COMPUTATIONAL BIOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Life Science BTC01		CT+MT+EA					
Course Outcomes	• CO1: To impart knowledge of life science and biological data • CO2: To acquire knowledge of computational and mathematical skills for addressing important biological questions. • CO3: To learn how to develop and implement computational algorithms and tools for processing biological data						
Topics Covered	1. Introduction to Computational biology and its applications(2) 2. Central dogma and biological macromolecules- DNA, RNA & proteins(2) 3. Major biological databases related to DNA, RNA, proteins &metabolic pathways(3) 4. Basic file formats & sequence representation(2) 5. Computational algorithms for Sequence Alignment: Local and global alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7) 6. Algorithms for phylogenetics: Tree constructions(5) 7. Structural Bioinformatics: A. Protein Structure and its visualization(2) B. Protein structural alignment(3) C. Protein secondary Structure Prediction(4) D. Protein tertiary Structure Prediction(4) E. RNA Structure Prediction(3) F. Molecular docking and docking algorithms(3) 7. Application of machine learning in biological sciences (Basic concepts) (2)						

Text Books, and/or reference material	Suggested Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. Introduction to Bioinformatics by Arthur MLesk Suggested Reference Books: 1. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R.Taylor. 2. Essentials of Bioinformatics by JinXiong

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 551	IMMUNOLOGY LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA					
		CT+EA					
Course Outcomes	CO1: To learn the fundamentals of immunological techniques CO2: To be able to perform techniques routinely used in immunology, particularly the use of specific antibody in biomolecular applications. CO2: To be able to isolate, count and identify different types of blood cells. CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results. CO5: To understand the basic hazards of working with human samples and antigens and safety measures to be taken						
Topics Covered	1. Cell count with Haemocytometer 2. Determination of viability of the cells 3. Serology: Preparation of the blood smear 4. Blood cell identification 5. Blood grouping by Agglutination assay 6. Quantitative WIDAL test (By tube test and slide test) 7. Precipitation test: Immunodiffusion 8. Enzyme linked Immunosorbent Assay (ELISA) 9. Protein detection by Western blot technique. 10. Lymphocytes isolation using FicollHypaque technique						

Text Books, and/or reference material	Suggested Text Books: 1. Immunology Laboratory manual. 2. ArtiNigam,ArchanaAyyagari,"Lab Manual in Biochemistry, Immunology and Biotechnology",McGraw Hill Education, India, 2007 Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS-552	BIOPROCESS TECHNOLOGY LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+ EA					
Course Outcomes	CO1: To learn about surface culture fermentation in lab scale CO2: To learn about submerged culture fermentation in lab scale and various assays for antibiotics production, polysaccharide production and cell growth determination CO3: To learn about cell immobilization by entrapment method						
Topics Covered	1. Production of neomycin by fermentation 2. Production of citric acid by fermentation 3. Production of xanthan/dextran gum by fermentation 4. Production of Bakers yeast by fermentation 5. Cell Immobilization by entrapment method						
Text Books, and/or reference material	Suggested Text Books: 1. Experimental Process Biotechnology Protocols, S N Mukhopadhyay, Viva Books, 2007. Suggested Reference Books:						

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHS581	UNIT OPERATIONS OF CHEMICAL ENGINEERING LABORATORY II	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Unit operation of Chemical Engineering I and II		CT+MT+EA					
Course Outcomes	● CO1: Apply the knowledge of fundamentals of heat and mass transfer equipment on laboratory ● CO2: Experimentation and data analysis ● CO3: Handling various instruments and solve various difficulty levels ● CO4: Learn industrial applications of heat transfer equipment ● CO5: Complete process design through assignment / group task						
Topics Covered	● Determination of thermal conductivity of metal rod ● Determination of overall heat transfer coefficient in a counter-current & parallel flow double pipe heat exchanger. ● Determination of overall heat transfer coefficient in a shell and tube heat exchanger. ● Experimental test rig on drop-wise and film-wise condensation for assessing the performance. ● Studies on estimation of hold-up volume under steady state condition and evaluate the overall performance of a rotary dryer. ● Determination of overall efficiency of cooling tower ● Estimation of rate of drying of specific biomass under steady state condition in a atmospheric tray dryer ● Performance studies on continuous fractionating distillation column in terms of distillate, bottom product and reflux quantities, % loss, % recovery, energy consumption etc. 36 hr						
Text Books, and/or reference material	Suggested Text Books: 1) Transport Processes and Unit Operations - C. J. Geankoplis 2) Heat Transfer: Principles and Applications: B. K Dutta Suggested Reference Books:						

SIXTH SEMESTER

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	ECONOMICS AND MANAGEMENT ACCOUNTANCY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• To review basic economic principles with students; • To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works; • To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.
Topics Covered	PART 1: Economics Group A: Microeconomics Unit 1: Economics: Basic Concepts Unit 2: Theory of Consumer Behaviour Unit 3: Theory of Production, Cost and Firms Unit 4: Analyses of Market Structures: Perfect Competition Unit 5: Monopoly Market Unit 6: General Equilibrium &Welfare Economics Group B: Macroeconomics Sl. No. Name Unit 1: Introduction to Macroeconomic Theory Unit 2: National Income Accounting Unit 3: Determination of Equilibrium Level of Income Unit 4: Money, Interest and Income Unit 5: Inflation and Unemployment Unit 6: Output, Price and Employment PART 2: Accountancy Sl. No. Name Unit 1: Introduction to Accounting Unit 2: Primary Books of Accounts (Journal) Unit 3: Secondary Books of Accounts (Ledger) Unit 4: Cash Book Unit 5: Bank Reconciliation Statement Unit 6: Trial Balance Unit 7: Final Accounts

Text Books, and/or reference material	Suggested Text Books: PART 1: Economics Group A: Microeconomics 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics Group B: Microeconomics 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. SoumyenSikder: Principles of Macroeconomics PART 2: Accountancy 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC601	BIOINFORMATICS	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Cell Biology and Genetics (BTC301), Biochemistry and Enzyme Technology (BTC303), Programming and Data Structure (CSC431)		CT+MT+EA					

Course Outcomes	• CO1: To learn how to integrate both biological and computer skills for addressing important biological questions. • CO2: To acquire knowledge of existing biological databases and understand the methods for storing, organizing, retrieving and analyzing biological data in an efficient way. • CO3: To learn and implement computational algorithms and tools (webservers and standalone programs) for processing biological data

Topics Covered	1. Introduction to Bioinformatics and its applications (2) 2. Linux and Bash programming for bioinformatics (3) 3. Major Information Resources & biological databases (3) 4. Sequence Alignment: Sequence similarity, Sequence identity, Sequence homology, Gap Penalty, local and global alignment, pairwise and multiple alignments, sequence alignment algorithm, Dynamic programming, BLAST and PSI-BLAST, Application of BLAST tool, Concept of Scoring matrix (5) 5. Molecular phylogeny and evolution: Phylogenetics basics and methods for phylogenetic tree constructions (4) 6. Structural Bioinformatics: A. Protein Structure and its visualization, structural alignment (3), B. Protein secondary Structure Prediction (2), C. Protein tertiary Structure Prediction (2), D. RNA Structure Prediction (2) 7. Molecular Docking and Drug design (Basic concepts) (2)
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. Introduction to Bioinformatics by Arthur M Lesk <u>Suggested Reference Books:</u> 1. Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck 2. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R. Taylor. 3. Essentials of Bioinformatics by Jin Xiong

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC631	DATABASE MANAGEMENT SYSTEM	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Understand the basic concepts and appreciate the applications of database systems CO2. Comprehend the fundamentals of design principles for logical design of relational databases CO3: Apply the query writing skill CO4. Discuss the basic issues of transaction processing and concurrency control
Topics Covered	1. Introduction of DBMS. 5L 2. Concept of E-R diagram, Extended E-R diagram. 5L 3. Relational Algebra 4L 4. Queries with various operations 4L 5. SQL Queries 4L 6. Index structure design 5L 7. Normalization (Different normal forms) 5L 8. Basic concepts on transaction processing 5L 9. Various concurrency-control protocols (2 phase locking, time stamp protocol) 5L
Text Books, and/or reference material	Suggested Text Books: 1. Silberschatz, H. F. Korth and S. Sudharshan, “Database System Concepts”, Sixth Edition, Tata McGraw Hill, 2011. 2. R. Elmasri, S. B. Navathe, “Fundamentals of DBMS Systems”, Pearson education. Sixth Edition. 3. Kahate, “Introduction to Database Management Systems”, Pearson Education, New Delhi, 2006. Suggested Reference Books: 1. C.J.Date, A.Kannan and S.Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC631	Process Control & Instrumentation	PCR	2	1	0	3	3
Mathematics, Unit Operations		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Analyze open-loop system • CO2: Analyze and apply the knowledge of linear closed-loop systems. • CO3: Develop working knowledge of control system by frequency response • CO4: Analyze the response of instruments and ability to integrate knowledge about instrument • CO5:Explain the importance and application of instruments
Topics Covered	Laplace Transform, 1st order response, 1st order in series, linearization, 2nd order Dynamics (12) Feedback control system, Servo and regulator problem, Transfer function of Controller, Final control element, Control valve characteristics, Transportation Lag, Routh-Hurwitz Criteria and stability (12) frequency response of closed-loop, frequency response technique, Bode Diagram and stability criteria (8) Static and dynamic responses, Measurement of temperature and pressure (5) instruments for process plant to measure flow, level and concentration of fluid (5)
Text Books, and/or reference material	Suggested Text books: 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. Chemical Process control, G. Stephanopoulos, PHI, 2008 3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996) 4. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000) Suggested Reference Books: 1. Jone's Instrumentation Technology (all the volumes) 2. Instrumentation and Devices by Rangan& Sharma 3. Considine's Handbook on Instrumentation 4. Atomic absorption and Emission Spectrophotometers, Ed Metcalfe 5. Industrial Instrumentation, D.P.Eckman

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE610	Animal Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	CO1: To elucidate the scope of Animal Biotechnology. CO2: To learn the different areas of Animal Biotechnology applications. CO3: To learn the basic technology in each area of Animal Biotechnology. CO4: To learn the future prospect of the Animal Biotechnology.						

Topics Covered	**Animl Cell culture:**History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions. Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization (8) **Technology – Present and future :** Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering (4). **In Vitro Fertilization and Embryo Transfer:** Basic knowledge on Fertilization and embryology, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA (4) **Stem cells:** Classification and types, Sources, Markers, Differentiation signals, application, IPSC, Cncer stem cells (4). **Gene Therapy:** Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system, Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vector system, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents (4) **Transgenic and Konck out Animals:** Methodology, Embryonic Stem Cell method, Microinjectionmethod, Retroviral vector method, Applications of transgenic animals **Recombinanat protein expression and purification:** Expression vectors for mammalian proteins, Cell (S cerevicea, P pasturis etc.) for large scale mammalian protein production, Post translational modification and purification.
Text Books, and/or reference material	Suggested Text Books: 1. Animal Cell Culture by John R.W. Masters; Oxford University Press Suggested Reference Books: 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts; Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BTE611	Industrial Microbiology	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To interpretbasic concepts for the production of microbial products.fermentation and separation technology CO2: To learn about the different types of Bioreators and their use. CO3: To analyse the principles, and techniques for improving the yield and desired properties in via strain improvement strategies. CO4: They will be able to apply the knowledge related to processes, equipment for industrial purpose and solve the problems.						
Topics Covered	**Industrial Microbiology– BTE611** **Introduction to Fermentation Technology: 12** Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. Types of Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; Media sterilization,.Preparation of microbial inoculum for Industrial fermentations. **Commercial strain development: 12** Induced mutations, Over producing decontrolled mutants, Catabolic derepressed mutants; Genetically engineered strain; Protoplast fusion technique. Improvement of strain by Site directed mutagenesis and Protein engineering : Definition, methods and application. Improving microbial strain forproduction of Amino acids Lysine and nucleosides and nucleotidesforaroma.Methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. **Microbial processes for production of valuables 10** Introduction, on Microbial growth and its kinetics.Primary and secondary metabolites and their regulation. Microbial production of organic acids, antibiotics,alcohol, bakers yeast, Single cell protein (SCP); Vitamins.Organisms used,(wild and mutated). production method- process, recovery of products separation parameters , purification steps..Application . **Microbial Enzyme Technology: 10** Microbial process for production of enzymes.Commercial production of enzymes; amylases, proteases,cellulase.Enzyme Modification - site directedmutagenesis;Importance of Stability of enzymes;Enzyme stabilization by selection and protein engineering for T4 Lysozyme; Principles & techniques of immobilization of Enzymes, Application of immobilized enzyme in Industrial processes						

Text Books, and/or reference material	Suggested Text Books: 1. Industrial Microbiology, Casida L E 2. Biotechnology: A textbook of industrial microbiology: CruegerW ,Crueger A 3. Industrial Microbiology, Prescott & Dunn Suggested Reference Books: 1. Prescott's and Dunn's, A. Industrial Microbiology, 4th edition. CBS Publishers, New Dehli , India , 1987. 2. L.E. Cassida.Jr, Industrial Microbiology, New Age International Publisher 3. Atkinson.B and Marituna.F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ. Ltd. 4. Bailey &Olis, Biochemical Engineering Fundamentals, MGH. 5. Review papers from reputed international journals to convey the current progress .in this area.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE612	NUTRACEUTICAL AND NUTRIGENOMICS	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To establish the correlation between nutraceuticals with cell signaling pathway. CO2: To target nutraceuticals from different sources for prevention of disease. CO3: To understand the interaction between gut microbiota with functional food components and nutraceuticals and improvement of health. CO4: To formulate the concept of nutrient gene interaction for prevention of lifestyle related disorders.						

Topics Covered	Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals. **[8]** Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics and transcription factors. **[8]** Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds**.** **[5]** Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria **[7]** Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in Nutrigenomics **[12]**
Text Books, and/or reference material	Suggested Text Books: 1. Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput, Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John Shi , CRC Press 2. Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press Suggested Reference Books: 1. Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press 2. Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade 3. Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Haslr, Blackwell Publishing Professional

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<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE613</td><td>Human Genomics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="4">Pre-requisites</td><td colspan="4">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="4">Cell Biology and Genetics (BTC301), Biochemistry and Enzyme Technology (BTC303), Molecular Biology and rDNA Technology (BTC401)</td><td colspan="4">CT+MT+EA</td></tr>
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Course Outcomes	• CO1: To understand the general organization of human nuclear and mitochondrial genome and know about the salient features and characteristics. • CO2: To acquire knowledge the human genome project and its implication on clinical biology in the post genomic era. • CO3: To familiarize with different scientific techniques used for studying different features of genome. • CO4: To get an overview about different applications of the genomic based knowledge .
Topics Covered	1. Patterns of genome organization (10) 2. Structural genomics (2) 3. Functional genomics (2) 4. Reverse genetics (2) 5. Gene patenting (2) 6. Electronic PCR (2) 7. Genome mapping and genome sequencing (2) 8. Specialized database in molecular biology (2) 9. Human genome project progress (2) 10. Genes in health and disease(2) 11. Genomic disorders and molecular medicine (2) 12. Minimal cell Genome (2) 13. Prospects of Gene therapy in Human (2) 14. Pharmacogenomics (2) 15. Genebank (2) 16. Legal status of gene bank (2)
Text Books, and/or reference material	Suggested Text Books: 1. T. A. Brown, Genomes, John Wiley & Sons Suggested Reference Books: 1. Singer.M, and Berg.P, Genes and genomes, Blackwell Scientific Publication, Oxford ,1991 2. Beebe.T, and Burke.T, Gene Structure and Transcription, 2nd edition,1992, Oxford Univ Press 3. Glick and Pasteurneck, Molecular Biotechnology, Principles and Applications of Recombinant DNA technology, ASM Press 4. Strachan & Reed, Human Molecular Genetics, Garland Science. 5. Cantor & Smith, Genomics, John Wiley & Son

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE614	MOLECULAR VIROLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Cell Biology (BTC 301/BT 403), Molecular Biology (BTC 401/ BT 404), and Immunology (BTC 402/ BT 501)	CT+MT+EA
Course Outcomes	• CO1: Acquire an understanding of virus life cycle and host-virus interactions. • CO2: Acquire an idea about detection, prevention and treatment of virus infections. • CO3: To learn about use of virus in biotechnology.
Topics Covered	Brief history and principles of virology. (1) Principles of virus classification. (2) General structure of viruses; Viroids, Virusoids, Satellite viruses, and Prions. (2) Genome of plant and animal viruses. Mobile genetic elements. (4) Replications of RNA viruses. (5) Replication of DNA viruses. (5) Virus-cell interactions: cytopathology; virus entry and egress; host cell shut off and IRES; viral persistence and latency. (6) Methods to diagnose virus infections. (3) Antiviral vaccines. (3) Antivirals: interferons and its mechanisms of action. (2) Gene silencing. (2) Culture and purification of viruses. (2) Viral vectors and gene therapy. (2) New and emerging viruses (3)
Text Books, and/or reference material	Suggested Text Books: 1. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. Suggested Reference Books: 1. Fields Virology by Lippincott Williams and Wilkins.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 615	BIOMETTALURGY	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
Microbiology, Chemical Kinetics			CT+MT+EA				

Course Outcomes	**CO1:** To recapitulate the basics of bioenergetics and to understand the relevant biogeochemistry & microbiology. **CO 2:** To learn about the concepts of bioleaching and biobeneficiation along with the microbiological aspects **CO 3:** To learn about bioleaching processes with typical examples. **CO 4:** To analyze the kinetics of bioleaching **CO 5:** To understand the enzymatic mechanism of bioleaching.
Topics Covered	Recapitulation of basics of bioenergetics (ATP as an energy-rich molecule, oxidation-reduction reactions), Biogeochemical cycles – sulphur, iron, and manganese cycles. Nature and characteristics of biogeochemically important micro-organisms. (9) Bioleaching: definition, scope, advantages & disadvantages; Types: direct, indirect, & indirect contact. Types of bioleaching with respect to reaction intermediates (thiosulphate& polysulphide mechanisms). Autotrophs & heterotrophs as candidate microorganisms for bioleaching. Bioleaching by aerobic and anaerobic microorganisms. (9) Bioleaching processes: in situ, heap & dump, & reactor bioleaching. Bioleaching of copper by *Acidithiobacillus* from chalcopyrites, chalcocite, &covellite. Dump & heap and reactor bioleaching of copper. Uranium bioleaching &biobeneficiation of gold. Environmental pollution control in gold recovery processes. (9) Kinetics of pyrite bioleaching – two-subprocess mechanism- ferric leach kinetics & kinetics of bacterial oxidation of ferrous iron. Modelling of continuous tank bioleaching of pyrite – unsegregated and segregated models. (9) Oxidation of iron by Acidithiobacillus – enzymatic mechanism; role of cytochromes & rusticyanin, elements of electron transport pathways in iron & sulphur oxidation. (6)
Text Books, and/or reference material	Suggested Text Books: **1.** Pillai Abhilash, B. D. Pandey, K. A. Natarajan. Microbiology for Minerals, Metals, Materials and the Environment, CRC Press, 2018 **2.** Ross W. Smith &ManoranjanMisra, ed. Mineral Bioprocessing, The Minerals, Metals & Materials Society, 1991 Suggested Reference Books: 1. L. M. Prescott, J.P.Harley, D.A.Klein. Microbiology 5thedn. Mc-Graw Hill, 2002. 2. M.E. Curtin, Microbial mining and metal recovery biotechnology (1), pp 229-235, 1983 3. Woods D, Rawling D.E., Bacterial bleaching and biomining in marx J.L. (ed), Revolution in biotechnology, Cambridge University Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE616	NANOBIOTECHNOLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC01 (Life Science), PHC01 (Physics), CYC01(Chemistry)	CT+MT+EA
Course Outcomes	• CO1: Acquire an idea about nanoscale phenomenon • CO2: To learn about the basic investigation tools for the nanobiotechnology • CO3: To learn about bottom up and top down synthesis of nanosystems • CO4: to get comprehensive understanding of applications of nanotechnology in biology
Topics Covered	• Nanotechnology; introduction to miniaturization. (4) • Iinvestigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. Investigation tools: lithography (8) • Nanomaterials: organic and inorganic nanoparticles. Synthesis, assembly, and processing of nanostructures: phenomenon of self-assembly. (6) • Molecular self-assembly and bottom up synthesis of nanomaterials. (6) • Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6) • Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6) • Nanotoxicology. (4) • Future Concepts in Nanobiotechnology. (2)
Text Books, and/or reference material	Suggested Text Books: 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. Suggested Reference Books : 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 617	MARINE BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To learn about the bioprocess engineering aspects of marine products in commercial production CO2: To learn about the industrial applications of various marine products and their production CO3: To study the specific applications in energy, pharmaceutical and environmental sector.		
Topics Covered	**Bioprocess engineering of marine products**	Marine microbiology	3
		Photobioreactors – light regime	
		mass transfer and scale up, downstream processing of marine products	6
		Management of Marine production, Storage and transport.	4
		Marine natural products, valuable chemicals, bioactive compounds from micro-algae	4
	Specialized aspects	Cultivation of marine microorganism	3
		marine biomedical and bioactive compounds from marine organisms	3
		commercial bio-products from marine organisms	2
		biohydrogen production in photobioreactor, marine enzymes	3
		Marine bio-film and bio-remediation	3
		marine bio-sensor and transgenic marine organisms	2
		Marine Pharmacology: Potentialities in the Treatment of Infectious Diseases, Osteoporosis and Alzheimer´s Disease	3
		Molecular biodiversity	2
		marine products as biomarkers	2
		Economic and Regulatory Aspects of Marine Biotechnology	2
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: 1. Marine Bioprocess Engineering, J.G. Burgess R. Osinga R.H. Wijffels, Elsevier, 1999 2. Handbook of Marine Biotechnology, **Kim**Se-Kwon , Springer, 2015		

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 618	FOLDING, MISFOLDING AND DISEASES	PEL	3	0	0	3	3

BTC401- Molecular biology &rDNA Technology; BTC 303 Biochemistry & Enzyme Technology; BTC 301 Cell biology and genetics		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
		CT+MT+EA
Course Outcomes	• CO1: To acquire an understanding of the protein structure • CO2: To learn about the principles of protein folding and misfolding • CO3: To obtain a comprehensive idea of different diseases related to protein misfolding • CO4: Development of cumulative understanding of protein folding, misfolding and diseases to find much-needed cure for the relevant conditions.	
Topics Covered	Basic of protein misfolding related diseases. The hierarchical structure of the protein. Principles of protein stability and folding. (16) Protein misfolding and aggregation. Protein quality control: molecular chaperones, protein degradation, autophagy and aging. (12) Prion Diseases. Alzheimer's Disease. Parkinson's Disease. Huntington's Disease and other unstable repeat disorders. Amyotrophic lateral sclerosis and frontotemporal lobar degeneration. (14)	
Text Books, and/or reference material	<u>Suggested Text Books</u>: 1. Fundamentals of Neurodegeneration and Protein Misfolding Disorders by Martin Beckerman, Springer 2. Introduction to Protein Structure by Carl IV Branden, Routledge <u>Suggested Reference Books:</u> 1. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding by Alan Fersht, W. H. Freeman.	

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE619	ENGINEERING RESISTANCE IN PLANTS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC502 (Cell & Tissue Culture of Animals & Plants)		CT+MT+EA					

Course Outcomes	CO1: To develop the basic knowledge for genetic improvement of crop plants. CO2: Understanding the sources of useful genes required for engineering resistance. CO3: Learning of fundamentals of gene mapping and gene isolation. CO4: Learning the basics and methods of genetic transformation of plants. CO5: Solving problems related to biotic and abiotic stress faced by crop plants.
Topics Covered	**Introduction:** Principles of gene manipulation in plants and basic concepts of genetic improvement of crop plants**[5]** **Molecular markers & Cloning genes:** Identifying the good gene sources, general strategies for cloning genes from plants, Cloning methods based on DNA insertions, subtractive cloning, map-based cloning, chromosome walking, chromosome jumping, morphological markers, biochemical markers, molecular markers – RFLP, RAPD, AFLP, ISSR, RAMP, STMs, fingerprinting, SNPs**[10]** **Genetic Engineering:** Agrobacterium-plant interaction; virulence; Ti and Riplasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation Agrobacterium-mediated gene delivery; co-integrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation **[10]** **Applications:**Genetic engineering of resistance to biotic stress, tolerance to abiotic stress, removal of environmental pollutants, quality nutrition and health, molecular farming**[10]** **Biosafety concerns:** Removal of selectable markers from GM crops, Modern tools of genetic manipulation of plants; genome editing**[7]**
Text Books, and/or reference material	<u>Suggested Text Books</u>: 1. H.S.Chawla, Introduction to Plant Biotechnology, Oxford & IBH Publishing co. Pvt..Ltd 2. Slater.A.,NigelW.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press. 3. Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. 4. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub. <u>Suggested Reference Book</u>: 1. Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. 2. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. 3. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice 1996 Elsevier

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS651	MOLECULAR BIOLOGY AND rDNA TECHNOLOGY LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To understand the principle of isolation of nucleic acids through different techniques. CO2: To understand the techniques used in manipulation of nucleic acids. CO3: To develop expertise to apply the toolsof gene cloning and solve the problems associated with production of recombinant protein from genetically modified microorganisms. CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results CO5: To understand the basic hazards of working with nucleic acids and safety measures.
Topics Covered	1. Isolation of genomic DNA 2. Quantification of DNA 3.Agarose Gel Electrophoresis of DNA 4. Isolation of RNA 5. Agarose Gel Electrophoresis of RNA 6. Isolation of plasmid – agarose gel electrophoresis (quantitation and purity test) 7. Restriction digestion of plasmid – agarose gel electrophoresis 8. Bacterial transformation using plasmid having antibiotic resistant marker and some other genetic markers. 9. Southern Blotting 10. PCR technique
Text Books, and/or reference material	Suggested text Books: Suggetsed Reference Books: Sambrook et al., “Molecular Cloning” A Laboratory Manual

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS652</td><td>BIOINFORMATICS LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Programming and Data Structure (CSC431)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To acquire programming knowledge to analyze biological data
• CO2: To learn about different biological databases and retrieval of biological data in different file formats.
• CO3: To learn different bioinformatics softwares related to sequence, structure and phylogeny</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Bash programming (Linux commands) for data mining (3)
2. Handling Biological databases and sequence and structure retrieval (2)
3. Pairwise Sequence Alignment: BLAST tool and interpreting the results (1)
4. Multiple Sequence Alignment: Clustal, Muscle etc. (1)
5. Phylogenetics methods for phylogenetic tree constructions: Mega, Phylip (1)
6. C and Python scripts to analyse and interpret biological data (3)
7. Protein Structure and its visualization, structural alignment softwares: PyMOL, Rasmol, VMD (1)
8. Protein Structure prediction softwares: Modeller, I-Tasser, Psipred (1)
9. RNA related softwares: Vienna Package (1)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books</u>:
1. The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr.
2. Python Crash Course by Eric Matthews
<u>Suggested Reference Books</u>:
1. A Byte of Python by C.H. Swaroop
2. A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell</td></tr>
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Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS681	DATABASE MANAGEMENT SYSTEM LABORATORY	PCR		0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
1. Computer fundamentals, Data structures 2. Fundamentals of any computer programming languages		CT+EA					
Course Outcomes	CO1: Understand, appreciate and effectively explain the underlying concepts of database technologies CO2. Design and implement a database schema for a given problem CO3. Populate and query a database using SQL DML/DDL commands						
Topics Covered	1. SQL Queries 2. PL/SQL assignments						
Text Books, and/or reference material	Suggested Text Books: SQL and PL/SQL by Evan Bayross. Suggested Reference Books:						

SEVENTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1:To make budding engineers aware of various management functions required for any organization CO2:To impart knowledge on various tools and techniques applied by the executives of an organization CO3:To make potential engineers aware of managerial function so that it would help for their professional career CO4:To impart knowledge on organizational activities operational and strategic both in nature C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science
Topics Covered	**UNIT I:** Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization**(8)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7) **UNIT III:** Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8) **UNIT V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)

Text Books, and/or reference material	Suggested Text Books: • Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. • Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India • Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education • Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India • Operations Management, 7th edition (Quality control, Forecasting), Buffa&Sarin, Willey Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
BTE710	MOLECULAR PLANT PATHOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE), mid-term (MT) and end assessment (EA))					
BTC01		CE+MT+EA					

Course Outcomes	CO1: To understand molecular mechanisms of plant defense systems. CO2: To understand molecular mechanisms of pathogenesis. CO3: To have the idea to design strategies for protection of plants.
Topics Covered	Introduction to molecular plant pathology [1] Plant diseases [2] Plant disease development and environment [2] Effects of pathogen on plant physiology [2] Biochemistry of plant defense reactions [5] Plant-pathogen interactions [5] Genetic regulation of resistance in host plants [5] Genetic regulation of virulence in pathogen [5] Mechanisms of host defense [5] Mechanisms of pathogenesis [5] Biotechnological approach for plant protection; genetically modified plants to protect against pathogens [5]

Text Books, and/or reference material	Suggested Text Books: 1. Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. 2. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. Suggested Reference Books: 1. Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. 2. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer 3. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 711	CANCER BIOLOGY AND CELL SIGNALING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC301-Cell Biology and Genetics/BT-817- Cancer Biology		CT+MT+EA					
Course Outcomes	CO1: To understand the basic concepts of cancer biology and related cellular signalling CO2: To understand the development and causes of cancer. CO3: To understand the therapeutic aspects of cancer prevention CO4: To identify the target molecules that are associated with cancer so that the cancer preventive small molecule inhibitors/phytochemicals can be screened.						
Topics Covered	**Cancer Biology** Introduction to Cancer and Molecular basis of cancer [2] Mutation and DNA damage repair mechanism [2] Cell cycle [3] Oncogenes (tumor viruses) , Tumor suppressors [3] Epigenetics, non-coding RNAs and genome fluidity in cancer [4] Cancer and Stem Cells, Angiogenesis, Apoptosis [4] Cancer therapy, Future of Cancer research [3] **Cell Signaling related to cancer** Introduction to cellular signaling [3] Signaling molecules – (e.g. Hormones, Interferons and others) [3] Receptor-mediated signaling in cells [3] Role of different transcription factors and kinases (e.g. MAP kinases and other ser/thr kinases) [4]						

	Involvement of different signal transduction pathways during cancer initiation, progression and metastasis [5] Small molecule inhibitors of cancer [3]
Text Books, and/or reference material	Suggested Text Books: 1. Weinberg RA. The Biology of Cancer, 2nd Edition. Garland Science, 2013. 2. Cellular signal processing , 2nd Edition by Friedrich Marks, Ursula Klingmuller and Karin Muller-Decker, Garland Science Suggested ReferenceBooks: Selected reviews and primary scientific literature

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE712	FOOD BIOTECHNOLOGY	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation & increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant & nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.
Topics Covered	**Food for health and wellness [2]** **Food Microbiology: [6]** Detection of microorganism in food – role of PCR, DNA CHIP, rapid methods for identification of microorganism in food, immunological methods, Bioassay, Biosensors- detection of toxin, heavy metal , pesticide and herbicides **Food preservation [10]** Pasteurization, sterilization, Canning, Irradiation, Dehydration, low temperature Food preservation, use of preservatives, **Food fermentation [8]** Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages , dairy product, non beverage product , use of genetic engineering techniques for improved quality product.

	Genetically modified food **[6]** Fruit ripening, improvement of sweetness, flavor, starch, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Single cell protein, single cell oil, Spirulina, **Biotechnology in relation to food product and Food Safety** **(5+5)** Antioxidant, nutraceutical, Nutrigenomics Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series
Text Books, and/or reference material	Suggested Text Books: Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Suggested Reference Books: Fundamentals of Food Biotechnology by Lee

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE713	BIOPHARMACEUTICAL PROCESS DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To learn about the manufacturing process and facility design for biopharmaceutical products CO2: To acquire knowledge of detailed design of GMP compliant biopharma plant CO3: To study the design and optimization of downstream processes of therapeutic protein manufacture in a commercial set up CO4: To learn about technology transfer, regulation, validation and quality assurance of biopharma industry						

Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6] Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [12] Role of process development group and manufacturing group in biopharmaceutical process start up. [3] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [5] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [6]
Text Books, and/or reference material	Suggested Text Books: Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH Suggested Reference Books: Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE714	BIOENERGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	Learn about energy crisis, problems of fossil fuel use, global warming Learn about production of biological solid fuel. Learn about gaseous biofuel production like methane and hydrogen in detail. Learn about liquid biofuels Learn about benefits and deficiencies of biofuels, life cycle analysis
Topics Covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6] Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel. Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5] The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6] Jatropha cultivation, National hydrogen energy road map. [3]
Text Books, and/or reference material	Suggested Text Books. 1. Biofuels production, application and development. Alan Scragg, CABI. Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BTE715	PROJECT ENGINEERING FOR BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To learn about detailed design of a manufacturing plant CO2: To learn about cleaning, sterilization, waste management and utilities of a biotechnology production plant CO3: To study about Planning, construction and commissioning of a biopharmaceutical manufacturing plant CO4: To learn about project management and financial aspects of the plant						
Topics Covered	Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments & their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods [6] Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and cleanability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. [6] Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) [6] Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. [6] Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. [6] Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. [6] Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. [3] Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. [3]						

Text Books, and/or reference material	<u>Suggested Text Books</u>: Bioprocess engineering: system, equipment and facilities, B K Lydersen, NAD'Elia, K M Nelson. Wiley Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley <u>Suggested Reference Books</u>: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 716	STRUCTURAL BIOLOGY	PEL	3	0	0	3	3
BTC401- Molecular biology &rDNA Technology and BT C303 Biochemistry & Enzyme Technology		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To acquire understanding of the basic building blocks of life CO2: To learn about the most common structural motifs found in protein and DNA CO3: To understand the atomic level interaction between the protein and DNA CO4: To learn how to determine protein structure
Topics Covered	Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, folding and flexibility, DNA structures. (8) Structure, function and engineering - DNA recognition in prokaryotes by helix-turn-helix motifs. (4) DNA recognition by eukaryotic transcription factors, specific transcription factors (5) Enzyme catalysis with example of serine proteinases, membrane proteins, signal transduction, fibrous proteins (7) Recognition of foreign molecules by immune system, structure of spherical viruses (8) Prediction, engineering and design of protein structures, determination of protein structures (10)
Text Books, and/or reference material	<u>Suggested Text Books</u>: 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge <u>Suggested Reference Books</u>: Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE71 7</td><td>ENVIRONMENTAL BIOTECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn about air pollution monitoring and control
CO2: To learn about waste water treatment processes along with analytical procedures
CO3: To study about solid waste management
CO4: To acquire knowledge on bioremediation of pollutants</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Air pollution control methods and equipment - Primary and secondary air pollutants, Effect of air pollutants on health, Control of gaseous and particulate pollutants, air pollution control equipments. 6
Water pollution: sampling and analysis - Sampling, BOD and COD analysis, Bacteriological measurements, Numerical problems 5
Water and waste water treatment processes - Overview of treatment principles. Primary treatment – screening, sedimentation, flotation, neutralization etc. 4
Secondary treatment - Activated sludge process, extended aeration, Trickling filter, Aerated lagoons, Waste stabilization ponds, Aquatic plant systems, UASB reactors. Design of a complete mix activated sludge process. 8
Biomethanation. Nitrification and denitrification operations. Phosphorus removal. Sludge treatment and disposal. Tertiary treatment. Membrane based treatment processes. 8
Solid waste management, Vermiculture, hazardous waste management 5
Specialized aspects - Bioremediation for recovery of metals, Xenobiotics, Degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, Phytoremediation. Reactors in bioremediation. 6</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books</u>:
Introduction to waste water treatment processes, Ramalho, Elsevier.
Environmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. &Greogia; PHI
Waste water treatment and disposal, Arceivala, Wiley
Environmental Biotechnology, Alan Scragg, Oxford University press
<u>Suggested Reference Books</u>:
Waste water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill
Industrial Water Pollution Control, Eckenfelder, McGraw Hill.</td></tr>
</table>

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE718	PROTEOMICS AND PROTEIN ENGINEERING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC303 Biochemistry and Enzyme Technology; BTC401 Molecular Biology and Recombinant DNA Technology;		CT+MT+EA					
Course Outcomes	**CO1:** Students will acquire knowledge on protein structure and function and will be able to apply the understanding in designing strategies for proteomic analysis and protein engineering. **CO2:** Students will be acquainted with tools and techniques for proteomic analysis and will be able to analyze proteomic data using databases. **CO3:** Students will be acquainted with tools and techniques for protein engineering and will be able to apply them to solve problem related to protein function and efficiency.						
Topics Covered	**Introduction to proteinstructure and function:** Elementary ideas of bonding and structure, stereochemistry; spectroscopic techniques. Amino acid structure and properties to 3D structure of protein. Basic principles of protein folding anddynamics. Protein sequence andevolution. [10] **Proteomics and its application:** Chromatography principles. Analytical protein and peptide Separation, Protein Digestion Techniques, Mass Spectrometers for protein and peptide analysis, protein identification by peptide Mass fingerprinting. Mining proteomes, protein expression profiling, identifying protein-protein interactions and protein complexes, Mapping protein modifications. [16] **Protein Engineering:** Proteins design and engineering, Random, site directed mutagenesis; Strategies to alter catalytic efficiency; structure prediction and odelling proteins; Molecular graphics in protein engineering; Dynamics and mechanics; Drug-protein interactions and Design; applications of engineered proteins. [16]						

Text Books, and/or reference material	Suggested Text Books: R.M. Twyman; Principles of Proteomics, Bioscientific Publishers. Biotechnology, 2nd Edition 2015. David Clark and Nanette Pazdernik. Academic Cell. Suggested Reference Books: B.Alberts,D.Bray, J.Lewis et al, Molecular Biology of the Cell, Garland Pub. N.Y 1983. Richard J. Simpson, Proteins and Proteomics, I.K. International Pvt Ltd. Daniel C. Liebler, Introduction to Proteomics: Tools for the New Biology, Humana Press.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE719	MOLECULAR MODELLING &DRUG DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Biochemistry and Enzyme Technology, Bioinformatics		CT+MT+EA					
Course Outcomes	CO1: To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. CO2: To learn the fundamental concepts of structure-activity relationships CO3: To learn design of novel, biologically active compounds and Toelucidate the mechanism of action of drugs						
Topics Covered	Introduction to molecular Simulation Techniques (5) Quantum chemistry for Modeling of small molecules (5) Molecular Dynamics Methods- Molecular Dynamics of rigid non linear poly atomic molecules in ensembles, Structural information from M.D. (5) Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable forcefields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design: Principles of receptor based de novo ligand design. Rigid body molecular Docking. (7)						

Text Books, and/or reference material	Suggested Text Books: A R Leach-Molecular Modelling,. Principles and application 2nd edition–Prentice Hall. Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London Suggested Reference Books: G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley Scolnick.J.(2001) Drug Discovery and Design .Academic Press, London N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design.* Academic Press, San Diego, 1996.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE720	NANOTHERAPEUTICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1:To understand the role of the small molecules in the drug delivery system. CO2: To learn the fundamentals and principles of nanotechnologies in drug release system. CO3: To understand methods of nanotechnology in point of care diagnosis. CO4: To understand the basic mechanism of nanotherapeutics of tumours.
Topics Covered	**UNIT -I NANOPHARMACEUTICALS** **Nano-biotechnology for Drug Discovery** -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules . 5 Dendrimers, Nanobodies, Nanospheres-Nanotubes –Nano-cochleates.-Nano-molecular Valves for Controlled Drug Release –Nano-motors for Drug Delivery. 6 **UNIT - II ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES** **Development of nano medicines** – Nano Shells – Nano pores – Tectodendrimers – Nanoparticle drug system. Biomedical nanoparticles –Liposome's Different types of drug loading – Drug release – Biodegradable polymers. 5 Applications Nano biotechnologies for Single-Molecule Detection -Protease-Activated Quantum Dot Probes. 3 Nanotechnology for Point-of-Care Diagnostics –Nano diagnostics for the Battle Field – Nano diagnostics for Integrating Diagnostics with Therapeutics. 4 **UNIT – III APPLICATION IN CANCER THERAPY & NANOMEDICINE**

	Introduction and Rationale for Nanotechnology in Cancer Therapy -- Diagnostic approach by nano-sensing. 3 Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications. 5 Pharmacokinetics of Nano-carrier-Mediated Drug and Gene Delivery. 4
Text Books, and/or reference material	Suggested Text Books: 1. Kewal K. Jain, The Handbook of Nano-medicine Humana Press, (2008). Suggested Reference Books**:** Zhang, Nanomedicine: A Systems Engineering Approach” 1st Ed., Pan Stanford Publishing, (2005). Robert A. Freitas Jr., —Nano-medicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE72 1	BIOMATERIALS	PEL	3	0	0	3	3
BT C303 Biochemistry & Enzyme Technology, CYC01 Chemistry		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Classify the biomaterials and recognize their production and properties. CO2: Explain the application areas of biomaterials CO3: To realize the important basic properties and requirements for biomaterials CO4: Recognize the importance of relationships between living tissues and biomaterials
Topics Covered	Definition of biomaterials – biologically derived materials or materials compatible with biology. **(2)** Common biomaterials: some proteins, many carbohydrates and some specialized polymers. **(4)** Collagen (protein in bone and connective tissues): Structure production and its use. **(3)** Fibroin (protein in silk): Production and its use. **(2)** Production of these proteins by conventional cloning methods. **(3)** Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; **(8)** Biopolymers: Synthesis from a simple biological monomer (eghyaluronate polymers); Dextrans (used in chromatography columns); Rubberllike materials produced by bacteria and fungi (Polyhydroxybutyrate PHB), Poly-caprolactone (PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligeneseutrophus; Biodegradable polymers **(8)**

	Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. **(8)** Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems. **(4)**
Text Books, and/or reference material	Suggested Text Books: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Suggested Reference book: 1. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE722	VACCINE TECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC402 Immunology		CT+MT+EA					

Course Outcomes	CO1: To understand the factors that influence vaccine design and development CO2: To understand how research based discovery has driven vaccine development CO3: To know about the different types of vaccines CO4: To learn about the quality control and regulation in the vaccine production CO5: To understand the importance of vaccination as a public health strategy
Topics Covered	History of vaccine development- Importance of vaccines (2) Immunological response to vaccines (2) Vaccine design and development: Epitope identification; Vaccine efficacy, Adjuvants (6) Different types of vaccines: Inactivated toxins, Inactivated whole bacteria or viruses, Live attenuated bacteria or viruses; Subunit vaccines, Polysaccharide vaccines, Conjugated vaccines ; Recombinant DNA vaccines, Edible vaccines, Virus like particles(8) Next-generation vaccines: Human Immunome project; Human antibodies as vaccines (4) Production techniques used for vaccines (4) Storage and preservation of vaccines (4) Delivery methods: microspheres, nanoparticles; ISCOMS and immune modulators (6) Regulatory issues in vaccine production: OIE guidelines for production and seed lot management; Manufacturing recommendation; Final product release tests (5) Vaccine safety-the debate (1)

Text Books, and/or reference material	Suggested Text Books: New Vaccine Technologies: Ronald W. Ellis (Landes Bioscience), 2001. Vaccines: Stanley A. Plotkin, Walter A. Orenstein, Paul A. Offit(Elsevier), 6th Edition Suggested Reference Books: Medical Microbiology : Samuel Baron , 4th Edition (University of Texas) Advances in Vaccine Technology and Delivery: Cheryl Barton, Espicom Business Intelligence. "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries": Noel Mowat, Daya books.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE723	STEM CELL BIOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Cell Biology, Biochemistry, Genetics, Molecular Biology		CT+MT+EA					

Course Outcomes	CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signalling molecules and the use of such factors for tissue production in-vitro. CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodelling to correct these changes CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy. CO4: To understand the recent advances on application the regenerative therapy from well characterzied case studies.

Topics Covered	An Introduction to Stem Cells (2) Adult Stem Cells (1) Embryonic Stem Cells (1) Induced Pluripotent Stem Cells (1) Hematopoietic Stem Cells (1) Messenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) Molecular and Cellular Bases of Organ Development (6) Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals (4) Molecular Bases of degenerative disease (1) . Therapeutic Uses of Stem Cells with examples (2) . In vivo Regeneration of Tissues by Cell Transplantation (2) . IPS Cells as Experimental Models of Neurodegenrative Disorders: use of them as disease modelling platform, novel drug testing and tissue renerarative therapy and implantation studies(2) . Studies of Patients Treated with Stem Cells, The modalities of treatment, Preperation of cells/tissues/scaffolds and Trnasplantation procedure (3) . Tissue Regeneration Driven by Growth Hormones (2) . Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs (8) . Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)
Text Books, and/or reference material	Suggested Text Books: Stem Cells, Tissue Engineering And Regenerative Medicine By: David Warburton 1st Edition. Principles of Regenerative Medicine by Anthony Atala Robert Lanza Tony Mikos Robert Nerem , 3rd Edition. Translational Regenerative Medicine by Anthony Atala and Julie G. Allickson Suggested Reference Books: The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G. Tenth edition. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, IstEdtion.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE72 4	APPLICATIONS OF MOLECULAR CLONING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC401 (Molecular Biology &rDNA Technology)		CT+MT+EA					

Course Outcomes	CO1: To understand the fundamentals of molecular cloning. CO2: To learn the basic methods of molecular cloning. CO3:To gain knowledge about the potential application aspects of molecular cloning. CO4: To build-up a bridging concept for extension of theoretical knowledge to practical applications of molecular cloning.
Topics Covered	**Module 1: Basic principles of molecular cloning** Why gene cloning and DNA analysis are important (2) Vectors for gene cloning (2) Purification of DNA from living cells (2) Manipulation of purified DNA (3) Introduction of DNA into living cells (3) Cloning vectors for prokaryotes (3) Cloning vectors for eukaryotes (3) How to obtain a clone of a specific gene (2) Other molecular techniques (2) **Module 2: Applications of molecular cloning in research** Sequencing genes & genomes (3) Studying gene expression & function (3) Studying genomes (4) **Module 3: Applications of molecular cloning in biotechnology** Production of protein from cloned genes (2) Gene cloning & DNA analysis in medicine (3) Gene cloning & DNA analysis in agriculture (3) Gene cloning & DNA analysis in forensic science &environment (2)
Text Books, and/or reference material	Suggested Text Books**:** T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Seventh Edition, Wiley Blackwell. Suggested Reference Books: Sandy B. Primrose, Richard Twyman& Bob Old, Principles of gene manipulation primrose: An introduction to genetic engineering, Sixth Edition, Blackwell Science

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	GENETIC ENGINEERING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	**CO1:** Students will acquire basic understanding of molecules of life and their basic chemistry. **CO2:** Students will acquire knowledge of how genetic material stores programs of life and how that information is retrieved. **CO3:** Students will acquire knowledge of basic tools of genetic engineering and their applications. **CO4:** Students will be able to apply the acquired knowledge in understanding and solving biotechnology issues surrounding us.
Topics Covered	Structures of macromolecules such as Carbohydrates, Proteins, Enzymes, Lipids and Nucleic Acids. [10] Basics of cell biology, prokaryotes vs. eukaryotes, sub-cellular structures, their organization and functions. [10] Central Dogma of molecular biology, DNA Replication, Transcription, Reverse Transcription, Translation. [10] Basic tools of nucleic acid manipulation. Methods of genetic engineering; Genetic engineering of microbes, plants and animals.[12]
Text Books, and/or reference material	Suggested Text Books: Essential Cell Biology, 4th Edition, Albertset. al. Biotechnology.2nd Edition, 2015. David Clark and Nanette Pazdernik.Academic Cell. Cecie Starr, Christine A. Evers, Lisa Starr. Biology: Today and tomorrow with physiology. Suggested Reference Books: Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, Molecular Biology of the Cell, Garland Science. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT1002	Bioprocess Engineering	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: Strengthening of basic concepts of stoichiometry, kinetics, heat and mass transfer CO2: In depth learning of reactor design and operation for free and immobilized cells CO3: Learning of detailed processes of large scale mammalian cell and plant cell culture						

Topics Covered	Recapitulation: Stoichiometry of Growth and Product formation. Heat transfer for biochemical processes. Kinetics of Growth and Product formation in Batch, Continuous and Fed batch systems. 12 Media Sterilization and Air Sterilization. Design of Stirred Tank Bioreactors. 4 Mass transfer studies in stirred tank reactor and in free and immobilized cell bioreactors. 5 Design of Immobilized biocatalytic reactor, perfusion reactor, membrane reactor, Hollow fibre reactor, airlift reactor. Reactors for solid state fermentation. 5 Large scale mammalian cell culture – non perfused attachment system, fed-batch and perfusion for cell cultivation, suspension culture, microcarrier culture system, microencapsulation, large scale stirred tank and air lift reactors for cultivation of animal cell. Discussion on single use technologies. 10 Plant cell bioreactors – their design and operation. 3 Scale up, Instrumentation and Control of Bioreactors. 3
Text Books, and/or reference material	**Books** Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Bioreactors: Analysis & Design, Tapobrata Panda, McGraw Hill Doran PM, '*Bioprocess Engineering Principles*', Academic Press **Reference:** Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. International Cell Culture Technology for Pharmaceutical and Cell-Based Therapies, Sadettin Ozturk, Wei-Shou Hu, CRC Bioprocess Engineering: Kinetics, Biosystems, sustainability and reactor design by Shijie Liu, Elsvier Publisher.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC701</td><td>Modern Techniques in Biotechnology</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01, BTC401</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To get an exposure to the current status of genomic research and to develop an idea about several applications of genomics with respect to health and well-being.
CO2: To gain knowledge about advanced methods needed to study macromolecular structures and functions.
CO3: To gain exposure to tools involved in manipulation of nucleic acids; advanced genetic engineering and molecular biology tools as well as advanced microscopy and immunological techniques.</td></tr>
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Topics Covered	**Introduction to Genomics:** Importance of genomics; Sequencing of genomes; Assembly of genome sequences; The human genome project; Locating the genes in the genome; Determination of gene functions; Structural, comparative and functional genomics; Lessons from various prokaryotic and eukaryotic genomes; Comparative genomics in evolution and medicine; Genomic variations; Transcriptomes: measurement of gene expression; Genome and genome analysis; Bridging genomics to proteomics; Metagenomics. (14 classes) **Techniques for studying Macromolecular Structure.** Ultra centrifugation Sedimentation velocity and equilibrium determination of molecular weights; Electron microscopy; UV Visible Spectroscopy; Fluorescence Spectroscopy; Circular Dichroism Spectroscopy; Determination of protein 3D structure by Nuclear Magnetic Resonance spectroscopy; Determination of protein sequence by mass spectrometry. (14 classes) **PCR Techniques :**Multiplex, nested; reverse transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection. (3 classes) **Genome Editing Tools:** Gene silencing: introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy. Restriction Enzymes; Zinc finger nucleases, TALENs, CRISPR-Cas9hybridization techniques. (4 classes) **Protein-DNA Interaction:** Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase foot printing; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display, FRET (4 classes) **Microscopy and Immunological Techniques**: Application of following microscopes and microscopy techniques: Light and phase contrast; Fluorescence; Confocal; FRAP; TIRF; Electron (TEM and SEM); Electron tunnelling and Atomic Force Microscopy; Antibody generation, Flow cytometry (3 classes).
Text Books, and/or reference material	Suggested Text Books: 1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications. 2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Branden, Carl Ivar & Tooze, John (1999). Introduction to Protein Structure: 2nd Edition. Routledge, Taylor Francis Group: Garland Publishing. Suggested Reference Books: 1. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 2. Fersht, Alan. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding. 3 Relevant review articles/research papers/handouts/technical literature of companies provided in the course.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS751</td><td>BIOSEPARATION AND BIOCHEMICAL ANALYSIS LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td colspan="2">1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous assessment (CA), mid-term (MT) and end-term examination (ET))</td></tr>
<tr><td colspan="2">Bioseparation& Biochemical Analysis (BTC 503)</td><td colspan="7">CA+ET</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: To determine the specific cake resistance & filter medium resistance by constant pressure filtration/pressure-time variation in constant rate filtration
CO2: To prepare a cell-free extract by sonication/homogenization and identify a specific protein therein by Western Analysis
CO3: To learn the technique of salt precipitation of a protein and subsequent dialysis for removal of the salt and to get an idea of other equipment for concentrating a protein
CO4:To construct a binodial diagram and study the extraction of a protein in an aqueous two-phase system
CO5:To separate out a protein from a mixture by gel filtration/ion exchange chromatography and to concentrate a protein by ultrafiltration
CO6: To extract and estimate biomolecules such as lipids, DNA, & RNA</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Filtration (constant pressure filtration)
Preparation of cell-free extracts from cultured cells
3. Salt precipitation of protein and Dialysis
4. Extraction and estimation of total lipid content
5. Separation/concentration of proteins by Ultrafiltration.
6. Aqueous two phase extraction (binodial diagram)
7. Separation of proteins by gel permeation/ion-exchange chromatography
8. Identification of a specific protein present in the cell-free extract by Western Analysis
9. Determination of DNA and RNA concentration by UV absorption
10. Demonstration of lyophilisation & Rotary vacuum evaporation</td></tr>
</table>

Text Books, and/or reference material	Suggested Text Books: Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press Geankoplis, Transport Processes & Unit operations, PHI. Suggested Reference Books: Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 Shuler & Kargi, Bio-process Engg. PHI Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS752	CELL & TISSUE CULTURE LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC01 Life Science BTC301 Cell Biology and Genetics BTC 502 Cell and Tissue Culture	CT+EA

Course Outcomes	CO1: Students will be acquainted with basic plant tissue culture techniques. CO2: Students will be acquainted in basic animal cell culture techniques. CO3: Students will attain knowledge of application of cell and tissue culture techniques in academic and industrial laboratories. CO4: Students will have knowledge of biosafety and ethical issues related to cell and tissue culture.
Topics Covered	**Plant Tissue Culture** Preparation and sterilization of plant tissue culture media. Preparation of explants. Callus induction in rice. Regeneration of rice callus tissue. Rooting of regnerants in rice. **Animal Cell Culture** Sterilization Techniques, Preparation of Media & Preparation of Sera Primary Cell Culture Preparation of established Cell lines Cell Counting and Viability . Staining of Animal Cells & Preservation of Cells
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: 1. Laboratory manual

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 753	BIOCHEMICAL REACTION ENGINEERING LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					
Course Outcomes	To learn the experimental protocol of microbial growth and inhibition kinetics in a batch process To study substrate degradation, cell growth and product formation with immobilized cells in plug flow bioreactors. To learn about functions of a fermenter To study non-ideality in a plug flow reactor						
Topics Covered	1. Microbial cell growth kinetics 2. Microbial cell inhibition kinetics 3. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous packed bed reactor. 4. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous fluidized bed reactor. 5. Function of bioreactor- a) calibration of DO electrode. B) Calibration of pH electrode. 6. RTD studies in a packed bed reactor						
Text Books, and/or reference material	Suggested text Books: Suggested Reference Books: 1. Laboratory manual						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 754	VOCATIONAL TRAINING / SUMMER INTERNSHIP AND SEMINAR	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NA		EA					

Course Outcomes	CO1: To learn literature mining and acquire knowledge of presenting data in a proper format CO2: To enhance the communication skills of students CO3: Enable the students to face various kinds of audiences and develop self-confidence CO4: To learn application of ethical principles in various fields of research
Topics Covered	Each student is allotted a slot where he/she presents a scientific topic (related to the summer training they did in the previous semester)
Text Books, and/or reference material	Suggested Text Books: N.A. Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS755	PROJECT-I	PCR	0	0	3	3	1

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
All the Program Core subjects	CT+EA
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. Students are required to familiarize themselves with the literature review and scientific techniques and skills.
Text Books, and/or reference material	Suggested text Books: Suggested Reference Books: Related research papers.

EIGHTH SEMESTER

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO84 0	INDUSTRIAL BIOTECHNOLOGY	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Life science	CT+MT+EA

Course Outcomes	CO1- To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results CO-2 Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes CO-3 .Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques CO-4 Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation CO-5 Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation
Topics Covered	**UNIT 1 CELL CULTIVATION ,GROWTH KINETICS** -- 10 Hrs Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals.. **UNIT 2-MEDIA PREPARATIONand STERILIZATION** 10 Hrs Sterilization: basic concepts in sterilization insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter **UNIT 3- BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs** Purpose and importance of bioreactor, Parts of fermenter and types ;Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility'Operational modes of bioreactor: batch, semi-batch/fedbatch, continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor.

	UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and A PPLICATIONS -10Hour Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases). Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.
Text Books, and/or reference material	Suggested Text Books: 1. Pauline M. Doran, “Bioprocess Engineering Principles”, Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), “Fermentation Microbiology and Biotechnology”, CRC Press, 3rd Ed., 2011. Suggested Reference Books: 1. Ashok Pandey et al., “Enzyme Technology”, Springer Publisher, 2006. 2. Nielsen et al., “Bioreaction Engineering Principles”, Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), “Downstream Processing of Proteins: Methods and Protocols”, Humana Press, 2000. 4. Satinder Ahuja, “Handbook of Bioseparations”, Vol 2, Academic Press, 1st Ed., 2000.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO850	MEDICAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence. CO2: Able to analyze the key features therapeutics and drugs in current scenario. CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals. CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.

Topics Covered	**Microbial pathogenesis:** Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics. **Diagnosis of Infectious diseases**–Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy. **Drug Design and Drug delivery system :** Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques . New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics **Molecular Medicine:** Antibodies and vaccines-Therapeutic production of antibodies different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection . **Cell and tissue therapy** – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery **Clinical Toxicology**, **Clinical Research Governance and Ethics:** Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation& drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. . International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.
Text Books, and/or reference material	<u>Suggested Text Books:</u> Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA <u>Suggested Reference Books:</u> Pharmaceutical Biotechnology ; Sambhamurthy & Kar , NewAge Publishers Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London V. Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT2001</td><td colspan="2">Genomics, Proteomics and Bioinformatics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01, BTC401</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: In depth understanding of genomes, transcriptomes and proteomes to address relevant problems.
CO2: Learning bioinformatics to analyse genomes, transcriptomes and proteomes.
CO3: Development of comprehensive understanding of “Omes& Omics” to solve the existing problems of the society.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Introduction to genomics; Importance of genomics; (2)
Sequencing of genomes; Assembly of genome sequences; (2)
The human genome project; (2)
Locating the genes in the genome; (2)
Determination of gene functions; (3)
Structural, comparative and functional genomics; (2)
Lessons from various prokaryotic and eukaryotic genomes; (3)
Comparative genomics in evolution and medicine; Genomic variations. (2)
Introduction to proteomics: (1)
Expression proteomics, Functional proteomics, Structural proteomics; (2)
Two-dimensional gel electrophoresis (2-DGE); Sample Preparation; Isoelectric focusing (IEF); (3)
Equilibration of the IPG strip, the second dimension and detection of proteins on the 2-DGE gel; (2)
Introduction to mass spectrometry; Mass spectrometry (MS) - based methods of protein identification: (3)
MALDI-MS, ESI-MS; (3)
Analysis of phosphoproteins by MS; Glycobiology and proteomics; (2)
Protein microarrays; Protein 3D structures; (2)
Protein interaction networks; Measuring proteins. (2)
Introduction to bioinformatics; (3)
Data acquisition; Databases and data retrieval; (3)
Searching sequence database; Multiple sequence alignment, (5)
phylogenetics and sequence annotation; (3)
Structural informatics; (4)</td></tr>
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Text Books, and/or reference material	Text Books: 1. S. B. Primrose and R. M. Twyman; Principles of Genome Analysis 2. A. M. Campbell and L. J. Heyer; Discovering Genomics, Proteomics & Bioinformatics; Pearson ducation; Second Edition. 3. T. A. Brown; Genomes; Wiley-Liss; Third Edition. Mount "Bioinformatics" Cold Spring Harbour 4. Arthur Lesk "Introduction to Bioinformatics" 5. Bioinformatics Sequences and Genome Analysis, 2nd edition 2004 by David W. Mount, CBS Publishers and Distributors. 6. Daniel C. Liebler; Introduction to Proteomics: Tools for the New Biology; Humana Press. 7. Richard Twyman; Principles of Proteomics; 2nd edition; Garland Science. Reference Books: S. B. Primrose and R. M. Twyman; Genomics: Applications in Human Biology Bioinformatics. (A.D.Baxevanis&B.F.F.Ouellette, eds.) Wiley Interscience, 1998.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT2053	**Omics and Bioinformatics Laboratory**	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Genomics, Proteomics & Bioinformatics		CT+EA					
Course Outcomes	CO1: To acquire knowledge of most important bioinformatics databases and learn text- and sequence-based searches to retrieve biological data in different file formats. CO2: Understanding pairwise and multiple sequence alignment using various softwares. CO3: Perform phylogenetic analysis to understand evolutionary relationships. CO4: To learn prediction of secondary and tertiary structures of protein and RNA Sequences						
Topics Covered	1. Introduction and use of various sequence and structure databases. 2.Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, UniProt. 3.Pairwise Sequence Alignment: BLAST tool and interpreting the results 4.Multiple Sequence Alignment: Clustal, Muscleetc 5.Phylogeneticanalysisofproteinandnucleotidesequencesandphylogenetictree constructions using softwares like Mega, Phylip 6. Use of different protein family databases (SCOP,CATH). 7.Visualization of protein structures using Rasmol and PyMol.						

	8. Aligning protein structures. 9. Secondary structure prediction of proteins using DSSP, Pispred. 10. Homology modelling of proteins. 11. Using RNA structure prediction tools.
Text Books, and/or reference material	Text Books: The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr. Python Crash Course by Eric Matthews Reference Books: A Byte of Python by C.H. Swaroop A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS855	Project-II	PCR	0	0	6	6	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.						
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. Students are required to familiarize themselves with the literature review and scientific techniques and skills.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Related research papers.						

NINTH SEMESTER

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT 1051	**Bioprocess Engineering Laboratory**	PCR	0	0	4	4	2
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
Bioprocess Engineering							
Course Outcomes	**CO1**: To study the growth kinetics of E.coli and Saccharomyces cerevisiae in shake flasks and bioreactor **CO2:** To study the substrate utilization kinetics in a fermentation system **CO3:** To study the **S**terilization of a Bioreactor **CO4:** To determine Volumetric Oxygen Transfer Coefficient (K_La) in a Bioreactor **CO5:**To estimate Residence Time Distribution (RTD) in a Bioreactor **CO6:** To determine the correlation of Mixing Time with Reynold's Number in a fermentation system						
Topics Covered	1. Microbial Growth Kinetics 2. Determination Reducindg Sugar (Glucose) by Dinitrosalicylic acid (DNS) method 3. Media Sterilization and Air Sterilization 4. Aeration and Agitation in Bioreactors 5. Non ideal Flow in Bioreactors 6. Concept of Mixing Time determination						
Text Books, and/or reference material	Text Books: Reference Books: Mukhopadhyay S.N 2007. Experimental Process Biotechnology Protocols New Delhi Viva Books						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT3055	Major Project-I	PCR	0	0	22	22	11
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		NA					

Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. Students are required to familiarize themselves with the literature review and scientific techniques and skills.
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: Related Research papers

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT3056	Major Project Seminar- I	PCR	0	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		NA					
Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.						
Topics Covered	Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books:						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT4055	Major Thesis Project - II	PCR	0	0	22	22	11
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.						
Topics Covered	Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:** Related research papers.						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT4056	Major Project Seminar-II & Viva Voce	PCR	0	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					

Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.
Topics Covered	Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:** Related research papers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT4057	Comprehensive VIVA VOCE	PCR	0	0	0	0	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NA		EA					
Course Outcomes	**CO1:** To prepare the students to face future interviews. **CO2:** To develop logical thinking skills in the students.						
Topics Covered	1. All the topics taught in core courses. 2. Topics taught in the elective courses.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:**						

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9031</td><td>Human Molecular Genetics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Genetics and Molecular Biology</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">1. Learn about classical human genetics.
2. Learn about Mutation and diseases.
3. Learn about genetics of Neoplasia.
4. Learn about genomic imprinting and human disease
5. Learn about X-inactivation and DNA methylation.
6. Learn about gene mapping and positional cloning.
7. Learn about genetics of behavioral disorders
8. Learn about pharmacogenetics and biochemical genetics.
9. Learn about animal models in human genetics
10. Learn about methods used for diagnosis and detection of gene mutations</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1.Simple Mendelian traits.
Loss-of-function mutations; Gain-of-function mutations; Gene interactions;Dynamic mutations.
3.Genetics of neoplasia.
4.Genomic imprinting and human disease.
5. X-inactivation and DNA methylation
6. Gene mapping and positional cloning etics of behavioral disorders. Maco-genetics and biochemical genetics. mal models in human genetics. methods used for diagnosis and detection of gene mutations.</td></tr>
<tr><td>Text/ References</td><td colspan="7">1. Human Molecular Genetics : Tom Strachan and Andrew P Read
2. Thompson and Thompson Genetics in Medicine
3. An Introduction to Human Molecular Genetics: Jack J. Pasternak 4.Molecular Biology of the Gene: James D Watson
5. Genes IX: Benjamin Lewin
6. Concept of Genetics: Klug, Cummings and Spencer
7. Molecular Cell Biology: James E. Darnell
8. Molecular Biology of Cancer: Pecorino</td></tr>
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Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9032	**Cancer Biology**	PEL	3	0	0	0	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Genetics and Molecular Biology	CT+EA

Course Outcomes	1. Learn about classification of cancer, types and phenotypic characteristics. 2. Learn about DNA polymerase and DNA damage repairing mechanisms. 3. Learn about differentiation and apoptosis, Biology of metastasis, Carcinogenesis, Cancer genetics 4. Learn about Oncogenes and Tumor suppressor genes 5. Learn about Growth factors and signal transduction 6. Learn about Cell cycle regulation and check point. 7. Host tumor interactions, Gene rearrangements, detecting oncogene abnormalities in clinical specimens 8. Principles of chemotherapy, Concepts in cancer therapy - Mechanisms of cytotoxic drug action, Cancer Immunotherapy
Topics Covered	1. Phenotypic characteristics of cancer cells 2. DNA replication and Repair mechanisms 3. Role of differentiation and apoptosis, Biology of metastasis, Carcinogenesis, Cancer genetics 4. Oncogenes ,Tumor suppressor genes 5. Growth factors and signal transduction 6.Cell cycle regulation and check point.
	7. Host tumor interactions, Gene rearrangements, detecting oncogene abnormalities in clinical specimens 8. Principles of chemotherapy, Concepts in cancer therapy - Mechanisms of cytotoxic drug action, Cancer Immunotherapy.
Text/ References	1. The Biology of Cancer: Robert Weinberg 2. Principles of Cancer Biology: LJKleinsmith 3. Cancer: A Beginner's Guide (Beginner's Guides): Paul Scotting 4.Molecular Biology of the Gene: James D Watson 5. Genes IX: Benjamin Lewin 6. Concept of Genetics: Klug, Cummings and Spencer 7. Molecular Cell Biology: James E. Darnell 8. Molecular Biology of Cancer: Pecorino

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9033	**Signal Transduction**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))
Molecular Biology, Biochemistry, Cell biology and Genetics	CA+ET

Course Outcomes	CO1: Acquire an understanding on fundamental components of signal transduction processes. CO2: Acquire an understanding on various signaling steps in different physiological and developmental processes of bacteria, plants and animals. CO3: To be able to design experiments to investigate new signaling pathways and regulation of gene expression.
Topics Covered	Bacterial two-component regulatory systems (2) Ligands, Receptors, Second messengers and Effectors (3) Carriers and channels of membrane (1) G protein-coupled signal transmission (3) Protein tyrosine kinase (2) Ras/MAP Kinase pathways (2) Transcription factors and regulators (3) Chromatin remodeling (2) Ethylene signaling (1) Light perception and photoreceptors (2)
	Signal transducers and master regulators (3) Photomorphogenesis (2) Transcriptional networks of seedling development (2) Light regulated gene expression (2) Identification of novel signaling molecules (2) Functional characterization of new components (2) Cross talks among various signaling pathways (2)
Text Books, and/or reference material	Text Books: Lewin's Genes X by J.E. Krebs, E.S. Goldstein and S.T. Likpatrick Research Articles on the said topics (usually given to the students)

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9034</td><td>Molecular Cell Signaling</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Cell Biology, Molecular Biology and Biochemistry</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the concepts of molecular signaling of cells which regulate its function.
CO2: To understand the deregulation of these pathways leading to functional defects at cellular and molecular level.
CO3: To identify the molecules than can be targeted therapeutically for the treatment of human diseases at cellular and molecular level.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Introduction of cellular signaling [4]
• Signaling molecules – Interferons, Interleukins and others [4]
• Receptor-mediated signaling in cells, Receptor associated and non-receptor tyrosine kinases and their involvement in different signal transduction pathways [5]
• Role of different transcription factors and kinases (MAP kinases and other ser/thr kinases) [7]
• Activation of various signalling pathways (Jak-Stat, MAPK, PI3K-Akt, NF-kB etc.) in different cells by extracellular stimuli [10]
• Involvement of signal transduction pathways in many important cellular processes like
Cell migration, cancer, angiogenesis etc. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
Molecular Biology of the Cellby Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.6th Edition, 2014.Garland Science. olecular Cell Biologyby Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger,
Matthew P. Scott, Anthony Bretscher, HiddePloegh, Paul Matsudaira. 8th edition, 2016.</td></tr>
<tr><td></td><td colspan="7">Publisher: WH Freeman. Reference Books:
1. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp. 6th Edition, 2010. Wiley. Essential Immunology, Roitt, I.M., 9th Ed. (1997), Blackwell Scientific, Oxford, UK
2. Immunology, Kuby, J. 3rd Ed. (1997), Freeman, W.H,Oxford,UK
3. Weir, Immunology, 8th ed, W.B. Saunders& Co.
4. K.A. Abbas, Immunology, 4th ed, W.B. Saunders& Co.
5. Relevant publications from many peer-reviewed journals.</td></tr>
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<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) /Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9035</td><td>Food Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Bioseparation Technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO 1: To understand the concept of metabolic Engineering in food and apply it to increase the quality and productivity of food products
CO-2: To increase the efficiency of enzyme by protein engineering.
CO-3: To formulate associations between specific nutrients and genetic factors and to study how a food/food ingredient influence gene expression.
CO-4: To learn the concept of nutratceuticalsand help in the prevention of lifestyle related disorders.
CO-5: To study the application of nutratceutical in food based system and to develop delivery strategies for the nutraceutical.
CO-6: To learn about heat transfer, mass transfer and reaction kinetics in foods
CO-7: To learn about details of thermal processing of foods, dehydration operations and filtration operations art commercial level
CO-8: Studies on Food quality management and concept of HACCP CO-9: Studies on design of a food processing plant</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Food Biotechnology –
Food Microbiology- Metabolic Engineering of Bacteria for food ingredients, Metabolic engineering of Saccharomyces cerevisae (4]
Biotechnological Modifications of S. cerevisae and its effect in wine production, genetic Engineering of baker’s yeast, [2]
Recombinant Lactic Acid Bacteria [1]
Plant and Animal Food applications and functional food- Introduction to Nutraceutical and Nutigenomics, Probiotics, Bioavailability and delivery of nutraceuticals using nanotechnology Food and food component preventing cancer, Antiobesity effect of Allenic carotenoid, fucoxanthin, Encapsulation of probiotic bacteria, Antioxidant [10]
Improvement in Food Quality- Enzymes & Recombinant lipooxygenases and oxylipin metabolism for food quality [4]
Heat transfer in food, microwave operation, ultrasound assisted processing [4]
Kinetics of chemical reactions in foods [2]</td></tr>
</table>

	Dehydration of foods, Mass transfer in dehydration, Drying rate curve, Pychrometry [4] Physical separation processes in foods – filtration operation, membrane filtration [5] Food quality management, HACCP [3] Design of food processing plant [3]
Text Books, and/or reference material	Text Books Food Biotechnology by Kalidas Shetty Fundamentals of Food Biotechnology by Lee Fundamentals of Food Process Engineering, Romeo Toledo , Springer Fundamentals of Food Engineering, D G Rao, PHI References: 1. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals by Jean-Richard Neeser, J. Bruce German, CRC Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9036	**Biopharmaceutical Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	CO 1: To learn about the manufacturing processes of drug substance and drug products CO 2: To learn about the detailed design of a GMP compliant plant CO 3: To learn about downstream processing of biopharmaceutical products at commercial level CO 4: To learn about biopharmaceutical process start up CO 5: To learn about quality management in a biopharmaceutical industry						

Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6] Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [14] Role of process development group and manufacturing group in biopharmaceutical process start up. [2] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [4] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [4] Concepts of understanding controlling factors regulating cost of production of a biopharmaceutical product. [2]
Text Books, and/or reference material	Text Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH References Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9037	**Biomaterials**	PEL	3	0	0	3	3
Biochemistry, cell biology, Chemistry		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: Classify the biomaterials and recognize their production and properties. CO2: Explain the application areas of biomaterials CO3: To realize the important basic properties and requirements for biomaterials CO4: Recognize the importance of relationships between living tissues and biomaterials						
Topics Covered	Definition of biomaterials – biologically derived materials or materials compatible with biology. **(2)** Common biomaterials: some proteins, many carbohydrates and some specializedpolymers. **(4)** Collagen (protein in bone and connective tissues): Structure production and its use. **(3)** Fibroin (protein in silk): Production and its use. **(2)** Production of these proteins by conventional cloning methods. **(3)** Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; **(8)** Biopolymers: Synthesis from a simple biological monomer (eg., hyaluronate polymers); Dextrans (used in chromatography columns); Rubber Like materials produced by bacteria and fungi (Polyhydroxybutyrate PHB), Polycaprolactone(PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligeneseutrophus; Biodegradable polymers **(8)** Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. **(8)** Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems.**(4)**						

Text Books, and/or reference material	Text Book: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Reference book: 1. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9038	**Biometallurgy**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Microbiology, Chemical Kinetics	CT+EA
Course Outcomes	**1:** To recapitulate the basics of bioenergetics and to understand the relevant biogeochemistry & microbiology. **2:** To learn about the concepts of bioleaching and biobeneficiation along with the microbiological aspects **3:** To learn about bioleaching processes with typical examples. **4:** To analyze the kinetics of bioleaching **5:** To understand the enzymatic mechanism of bioleaching.

Topics Covered	Recapitulation of basics of bioenergetics (ATP as an energy-rich molecule, oxidation- reduction reactions), Biogeochemical cycles – sulphur, iron, and manganese cycles. Nature and characteristics of biogeochemically important micro-organisms. (9) Bioleaching: definition, scope, advantages & disadvantages; Types: direct, indirect, & indirect contact. Types of bioleaching with respect to reaction intermediates (thiosulphate & polysulphide mechanisms). Autotrophs & heterotrophs as candidate microorganisms for bioleaching. Bioleaching by aerobic and anaerobic microorganisms. (9) Bioleaching processes: in situ, heap & dump, & reactor bioleaching. Bioleaching of copper by *Acidithiobacillus* from chalcopyrites, chalcocite, & covellite. Dump & heap and reactor bioleaching of copper. Uranium bioleaching & biobeneficiation of gold. Environmental pollution control in gold recovery processes. (9) Kinetics of pyrite bioleaching – two-subprocess mechanism- ferric leach kinetics & kinetics of bacterial oxidation of ferrous iron. Modelling of continuous tank bioleaching of pyrite – unsegregated and segregated models. (9) Oxidation of iron by Acidithiobacillus – enzymatic mechanism; role of cytochromes & rusticyanin, elements of electron transport pathways in iron & sulphur oxidation. (6)
Text Books:	Text Books, and/or reference material Pillai Abhilash, B. D. Pandey, K. A. Natarajan. Microbiology for Minerals, Metals, Materials and the Environment, CRC Press, 2018 Ross W. Smith & Manoranjan Misra, ed. Mineral Bioprocessing, The Minerals, Metals & Materials Society, 1991 **Reference Books:** L. M. Prescott, J.P.Harley, D.A.Klein. Microbiology 5th edn. Mc-Graw Hill, 2002. M.E. Curtin, Microbial mining and metal recovery biotechnology (1), pp 229-235, 1983 Woods D, Rawling D.E., Bacterial leaching and biomining in Marx J.L. (ed), A Revolution in biotechnology, Cambridge University Press

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9039	**BioEnergy**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA

Course Outcomes	CO1: To learn about present energy scenario in the world and importance of alternate energy CO2: Detailed study on biological solid fuels CO3: Detailed study on biological liquid fuels to replace petrol and diesel CO4: Detailed study on biological gaseous fuels CO5: To learn about Indian scenario and approach to solve the problem
Topics Covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6] Liquid biofuels to replace petrol – methanol production.Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel.Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5] The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6] Jatropha cultivation, National hydrogen energy road map. [3]
Text Books, and/or reference material	**Text Books:** 1. Biofuels production, application and development. Alan Scragg, CABI. 2. Research articles

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9040	**Bioprocess & Plant Design**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Bioprocess Engineering, Bioseparation Technology	CT+EA

Course Outcomes	CO1: Learn about mass balance and energy balance in Bioprocess Engineering and Cell growth kinetics CO2: Learn about media sterilization and air sterilization including kinetics, design of batch and continuous media sterilizers and air sterilizers. CO3: Study of bioreactors and their design aspects related to microbial, plant and animal cell culture products CO4: Study of Scale-up, Operation, Instrumentation and control of Bioreactors. CO5: Bioreactor design supporting systems; Pumps, Refrigeration, Boilers and Effluent treatment plants. CO6: plant design aspects

Topics Covered	**Introduction to Bioprocess Engineering and Systems: (10)** Mass balance and energy balance in Bioprocess Engineering, kinetics of microbial growth, batch, continuous and fed batch systems, components of bioreactors, material of construction, vessel size, Aseptic operations in bioreactors, Mass Transfer and Heat transfer Bioreactors. Mechanical fittings in bioreactors ,Project planning in Bioprocess Engineering **Sterilization of Bioreactors: (6)** Media sterilization, kinetics of media sterilization, Arrhenius equation. Design of batch and continuous sterilizers Air sterilization, kinetics of air sterilization, Design of Air Filters **Bioreactors and their Design: (8)** Batch, continuous stirred tank Bioreactors (CSTR), Plug flow Bioreactors (PFR). Enzyme immobilized bioreactors ,Fluidized bed bioreactors, Bubble column bioreactors, Air- lift bioreactors, Hollow- fibre bioreactors, Membrane bioreactors Bioreactors for plant and animal cell culture systems **Scale-up, Operation, Instrumentation and control of Bioreactors: (4)** Scale up criteria, Measurement systems and their control in Bioreactors, Feedback control, Computer control Bioreactors. **Bioreactor design supporting systems: (6)** Reciprocating and Centrifugal Pumps; Boilers for Steam generation-Water Tube and Fire Tube boilers; Refrigeration systems; Effluent treatment systems-Aerobic and Anaerobic. **Plant Design (8)** Plant Location and Site Selection, Site layout, Utilities, Environmental considerations, Equipment cleaning, Culture cell bank, cGMP aspects, Bioprocess validation, Safety Considerations, Process economics.
Text Books, and/or reference material	Text Books: 1. Shuler M.L, Kargi F, '*Bioprocess Engineering-Basic Concepts'*, Prentice Hall of India Ltd. 2. Aiba S, Humphrey A E and Millis N F, '*Biochemical Engineering'* , Academic Press 3. Stanbury P F and Whitaker A, *'Principles of Fermentation* Technology', Pergamon Press 4. Bailey J E and Ollis D F, Biochemical Engineering Fundamentals,' McGraw Hill Reference Books: 1. Doran P M, 'Bioprocess Engineering Principles', Academic Press 2. Sinnott, R.K, 'Coulson and Richardson's Chemical EngineeringVol.3& Vol.6,', Butterworth-Heinemann

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9041	**Advanced rDNA & Cellular Biotechnology**	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Cell Biology, Biochemistry, Immunology, Molecular Biology & rDNA Technology, Microbiology	CT+EA

Course Outcomes	CO1 :Learn the concept about working of Host system , vectors.specfic enzymes CO2 : Formulate the strategies for r proteins from specific cells,media selection and their modification. CO3: By applying knowledge of cellular technologies, purification specific bioreactors can be setup for commercial level production of valuable compounds for mankind.
Topics Covered	**Module 1** : **Tools and general Methodology Recombinant DNA Technology**: Vectors types and their importance. Selection of host and its characteristics, Cloning and screening strategies for gene and gene expression with specific examples. (**6)** **Module 2** : **Manipulation in Gene Expression and Protein Production in Prokaryotes and Eukaryotes**;Regulatable promoters role; Vector design for increasing protein, Fusion protein , protein stability ; overcome oxygen limitation ,DNA integration into host chromosome, Metabolic load, Increasing Secretion ;Yeast espression system Cultured insect cell expression systems;Microbial Cell factories for insulin production.Modified microorganisms for waste degradation, Synthesis of commercial from recombinant microorganisms Ascorbic acid , Indigo, amino acids antibiotics, Engineering human interferon , Human growth hormones, DNAse I and Aginate lyase. **(10)** **Module 3 : Animal cells as Bioreactor**: Cultivation systems for cell and tissue culture: Animal cell cultures maintenance and modifications. Vector design for mammalian gene expression ; CHO cells and its modification to enhance its potential in production of

	recombinant proteins; Animal cell culture fermenter. Cell immobilization techniques. Large Scale Production of r Protein, Types of Fermenter ,Two stage fermentation in Tandem air lift reactor for T4 DNA Ligase. Separation of products.**(10)** **Module 4**: **Plants as bioreactors** for bio Pharmaceuticals production:Plant tissue culture techniques Cell suspension cultures and bioreactor technology, secondary metabolites, plant biosynthesis of alkaloids, flavonoids, terepenes, phenols, regulation and commercial importance.Plant and plant cell culture derived r Therapeutics and its purification.**(10) Module 5** : **Recent advanced tools** for Forensic studies,Molecular Diagnostics, Gene therapy. Environment cleaning programme.**(6)**
Text Books, and/or reference material	**Text/ Reference Books :** 1. Principles of Gene Manipulation. Old and Primrose- Blackwell scientific Pub. 2. Recombinant DNA Technology. Watson JD et al., Scientific American Book Series 3. Molecular biotechnology Principles and applications of r DNA technology. Bernard R.Glick.Jack J Pasternak. ASM Press ; Washington DC 4. Culture of Animal Cells: A Manual of Basic Technique. R. Ian Freshney Wiley-Liss. 5.Principles of Gene Manipulation. Sandy B. et al., Blackwell Publishers

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9042	**Animal Biotechnology**	PEL	3	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Genetics and Molecular Biology		CT+EA					
Course Outcomes	1. Learn about animal cell culture technique in laboratory scale. 2. Learn about technique for animal in large scale. 3. Learn about various techniques in animal biotechnology. 4. Learn about transgenic and knock animal techniques and its application. 5. Learn about techniques and importance of gene therapy 6. Learn about IVF technique and its importance. 7. Learn about stem cells and its applications.						

Topics Covered	1. History scope and prospect of animal cell culture: History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions.Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization. 2. Growth and scale up: Cell growth characteristics and kinetics, Micro-carrier attached growth, Cell culture in continuous, perfusion and hollow fiber reactor, Mass transfer in mammalian cell culture. 3. Technology – Present and future: Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering. 4. Transgenic and Konck out Animals: Methodology, Embryonic Stem Cell method,
	Microinjection method, Retroviral vector method, Applications of transgenic animals 5. Gene Therapy: Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system,Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vectorsystem, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents. 6.In Vitro Fertilization and Embryo Transfer:Composition of IVF media, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA. 7.Stem cells: Classification and types, Sources, Markers, Differentiation signals, application, IPSC
Text/ References	1. Animal Cell Culture by John R.W. Masters; Oxford University Press 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9043</td><td>Immunotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Immunology, Cell biology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO 1. The students will gain insight into the immune response to various infectious and non-infectious and autoimmune diseases.
CO 2. In depth understanding of the impact of different receptors cell signaling pathways in immune response will allow their knowledge to apply for future application.
CO 3. The latest technologies used in disease detection and antibody production
CO 4. To apply the concept and strategies for immunotherapeutics production from cell lines at higher scale.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamental and cell signaling in immune system: Components of innate and acquired immunity; major histocompatibility complex and immune responsiveness, molecular basis of antibody diversity, self–non-self discrimination and immunological memory. Immunoglobulin superfamily; B and T cell activation B-cell receptor; T-cell receptor; cytokines, chemokines and their receptors; signal transduction pathways. (8)
Host-Pathogen interaction; Molecular basis of Immune diversity, Immunity and infection to bacteria, virus, protozoa, fungi. tumor. Cancer, Auto immune disease, Inflammation. Discussion with examples for each category.Research on progress for immunotherapay (8)
Principles and applications of laboratory tests in Immunology: Principles of antigen-antibody interactions;production and purification of polyclonal antibodies; antibody assays - precipitation, agglutination, immunoelectrophoresis advanced immunological techniques - RIA, ELISA, Western blotting, immunofluorescence, immunoelectron microscopy, flow cytometry and ELISPOT assay, surface plasmon resonance; total and differential counts in human peripheral cells, separation of monocytes from peripheral cells; lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, HLA typing (6)</td></tr>
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	Cellular technologies and animal cell bioreactors : Large scale production of interferon, therapeutic agents. Generation of monoclonal antibodies through Hybridoma technology,. Use of specific cells and cell lines for therapeutic purpose. Genetic engineering techniques to make human antibodies- chimeric antibodies & humanized antibodies, clinical use of monoclonal antibodies. **(8)** **Vaccinology:** Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines; mRNA based vaccine, Peptide vaccines; conjugate vaccines, Dendritic cell vaccine; **(4)** **Clinical Immunology**- Hypersensitivity; Types of autoimmune diseases and their treatment; Transplantation and immunosuppressive therapy; Tumor immunology – Tumor antigens; Therapeutic uses of cytokines. **(8)**
Text Books, and/or reference material	**Text Book**: Kuby Immunology By Owen, Punt, & Stranford, 7th, Seventh Edition, 2013, Macmillan press. 2. Abul K. Abbas, Andrew K. Lichtman & Jordan S. Pober (Eds.). Cellular and Molecular Immunology. 3rd Edn. W.B. Saunders Company, 2001 **Reference books:** 2. The Elements of Immunology by FahimHalim Khan, Pearson Education, 2009. 3. Essentials of Immunology: Ivan Riot- Blakswell Scientific Publications, Oxford, 6th Edition. 4. Infection and immunity by John Playfair and Gregory Bancroft, 3rd edition, Oxford Univ.press. 2008. 5. Monoclonal antibodies: Principles and practice by J.W. Goding. 3rd edition, Academic Press.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9044	**Molecular Modeling & Drug Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Proteomics, Protein Engineering		CT+EA					

Course Outcomes	CO1: To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. CO2: To learn the fundamental concepts of structure-activity relationships CO3: To elucidate the mechanism of action of drugs (drug-receptor interaction) CO4: To learn rational design of novel, biologically active compounds.
Topics Covered	Introduction to molecular Simulation Techniques (5) Quantum chemistry for Modeling of small molecules (5) Molecular Dynamics Methods- Molecular Dynamics of rigid non linear polyatomic molecules in ensembles, Structural information from M.D. (5) Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable force fields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design: Principles of receptor based de novo ligand design. Rigid body molecular Docking. (7)
Text Books, and/or reference material	Text Books: A R Leach-Molecular Modelling,. Principles and application 2nd edition– Prentice Hall. Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London Reference Books: G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley Scolnick.J.(2001) Drug Discovery and Design Academic Press, London N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design.* Academic Press, San Diego, 1996.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9045</td><td colspan="2">Regenerative Medicine & Translational Research</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Cell Biology, Biochemistry, Genetics, Molecular Biology</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signaling molecules and the use of such factors for tissue production in-vitro.
CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodeling to correct these changes
CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy.
CO4: To understand the recent advances on application the regenerative therapy from well characterized case studies.</td></tr>
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Topics Covered	An Introduction to Stem Cells(2) Adult Stem Cells (1) Embryonic Stem Cells (1) Induced Pluripotent Stem Cells (1) Hematopoietic Stem Cells (1) Mesenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) Molecular and Cellular Bases of Organ Development (6) Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals(4) Molecular Bases of degenerative disease (1) Therapeutic Uses of Stem Cells with examples (2) In vivo Regeneration of Tissues by Cell Transplantation (2) IPS Cells as Experimental Models of Neurodegenerative Disorders: use of them as disease modelling platform, novel drug testing and tissue regenerative therapy and implantation studies(2) Studies of Patients Treated with Stem Cells, The modalities of treatment, Preparation of cells/tissues/scaffolds and Transplantation procedure(3) Tissue Regeneration Driven by Growth Hormones (2) Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs(8) Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)
Text Books, and/or reference material	Text Books: Stem Cells, Tissue Engineering And Regenerative MedicineBy: David Warburton 1stEdition. Principles of Regenerative Medicine by AnthonyAtala Robert Lanza Tony Mikos Robert Nerem,3rd Edition. Translational Regenerative Medicine byAnthony Atala and Julie G. Allickson Reference Books: The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G.Tenth edition. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, IstEdtion

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9046	**Microbial Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Cell Biology and Genetics Biochemistry and Enzyme Technology, Microbiology and Fermentation Technology	CT+EA
Course Outcomes	CO1: To acquire knowledge on microbial based products of commercial importance at environmental ,industrial and clinical relevance. CO2:To Apply knowledge based skills in developing strategies to improve yield and reduce cost of the microbial process and or derived products CO3:To generate pilot plant design via understanding in microbial kinetic studies. and scale up approaches. CO4:Able to impart the knowledge in synthesis and separation of microbial products at highest level of purity as per the required demand.
Topics Covered	UNIT 1:An overview of traditional and modern applications of microbial products. Concept of Overproduction of metabolites. Strain improvement strategies for improved production of valuables via Classical (Random Mutagenesis)and advanced approches(Genetic engineering, Site directed mutagenesis, Protoplast fusion). Case studies on strategies for enhanced production of Insulin, Penicillin, and enzymes of microbial origin with emphasis onhost cell engineering ;vector design, optimization of media and process parameters. Concepts on cost analysis for better yield using improved technology (10) UNIT 2: Process technology for the production of microbial biomass. , primary metabolites and secondary metabolites. Growth and product kinetics .Fermentation, raw materials for fermentation, submerged, surface and solid-state systems, whole cell and enzyme immobilized systems.Technological processes for industrial manufacture of Yoghurt, acidophilus milk, Koumis, kefir, cheese, bread, alcoholic beverage, vinegar. Lactic acid and oriental fermented food of commercial importance. Equipment involved in the commercially important food processing methods.(10) UNIT 3: Different regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes, Induction, nutritional repression, carbon catabolite repression, Crabtree effect, feedback inhibition and feedback repression, with respect to biomass and valuables production.Case studies on Heterologous gene expression and secretion in Gram-positive bacteria with industrial applications. Biotechnology of protein secretion systems in Escherichia coli.(10)

	UNIT4:Environmental factors and stress in Bacterial community and their response.Microbial waste degradation (Heavy metal ,phenolics,and hydrocarbon); Microbes in bioenergy production (bioethanol , biobutanol,algal biofuel); Application based perspectives of Metagenomics. Plant microbe interaction microbe-mediated enhancement of nitrogen and phosphorus content for crop improvement; Genetic control of the cell cycle and microbial pathogenesis.(10) UNIT 5: Primary & secondary separation process for recovery of microbial products - Biomass removal . Biomass disruption , Membrane based techniques. Extraction -solvent, aqueous two phases, super critical, and Adsorption. Chromatography, Precipitation

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9047	**Environmental Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Microbiology, Molecular Biology, Biochemistry		CT+EA					
Course Outcomes	Learn about scope, applications (pollution prevention and abatement) and different parameters in the field of Environmental Biotechnology. Learn about different modes of microbial interaction with inorganic and organic pollutants. Learn about aerobic and anaerobic biotransformation mechanisms and about the scope of genetically engineered organisms in bioremediation. Learn about role and requirements of microorganisms, Microbial community composition and the interactions between community members for enhanced bioremediation. Learn about different strategies of bioremediation – in-situ bioremediation approaches, ex-situ bioremediation approaches, biostimulation, bioaugmentation, monitored natural attenuation, phytoremediation. Learn about different factors regulating bioremediation. Learn about waste water characteristics. Learn about effluent treatment processes. Learn about various suspended growth Aerobic effluent treatment processes. Learn about various attached growth Aerobic effluent treatment processes. Learn about Anaerobic digestion process. Learn about design of reactors for effluent treatment processes.						

Topics Covered	Unit 1-Introduction to Environmental Biotechnology: definition, scope of applications; Biotechnology for pollution prevention and pollution abatement (green technologies – bioleaching of metals, microbially enhanced oil recovery, biodegradable polymers, biobleaching, biodesulphurization, biofuel production, biogas, bioremediation, etc.) (3) Unit 2 -Types of pollutants, sources of pollutants, magnitude of contamination problem, merits and limitations of bioremediation, bioremediation of organic and inorganic pollutants. Microbial interactions with heavy metals/radionuclides – bioaccumulation, biosorption,
	biotransformation, bioprecipitation, applications of metal-microbe interactions, biomining, engineering microorganisms for metal bioremediation (3) Unit 3 - Biodegradation principles – microbial processes, biotransformation, mineralization, detoxification, activation, cometabolism and growth associated degradation. Requirements for biodegradation, cooperation between different microbial species for enhanced biodegradation, Implications of recalcitrance, acclimation, biotransformation mechanisms – genes, enzymes, reactions, Biodegradation pathways and metabolites, effect of contaminant structure on biodegradability. (8) Unit 4 -Bioremediation strategies – microbial community composition and interactions between community members for enhanced bioremediation, natural attenuation and accelerated bioremediation, aerobic, anaerobic, ex-situ bioremediation approaches, in-situ bioremediation approaches, biostimulation, bioaugmentation, Phytoremediation - phytoextraction, rhizofiltration, phytodegradation, phytovolatilization, rhizoremediation, phytostabilization. (8) Unit 5 -Waste Water & Sludge treatment:Characteristics and analysis of waste water, Treatment of waste water of sewage & Industry. Bio-kinetics coefficient and its application in waste water treatment. Basic design concepts and calculations for waste water treatment of:Preliminary treatment units – screening,grit removal , removal of oil and grease; Primary treatment units-settling tank, flotation.Biological treatment:Aerobic: Activated sludge process, secondary settling tank, trickling filter, waste stabilization pond.Anaerobic : Anaerobic reactors for treatment of waste water- Anaerobic Digesters, Upflow Anaerobic Sludge Blanket Reactor(UASB), Fluidized Bed Biofilm Reactor(FBBR), Treatment and disposal of sludge, Solid waste management , Advanced Waste Water Treatment-Limitations of conventional treatment, pathogen removal, toxic substances removal, phosphorous and nitrogen removal (12) Unit 6 -Industrial Waste:Approach to design, process design parameters - Characteristics, analysis and treatment of wastes from different Industry like: dairy industry, fermentation, slaughter house, tanning, dye, pulp and paper, distillery, petroleum, heavy metal pesticides, food and beverage, antibiotics etc. Treatment of biological industry wastes, Treatment & disposal of radioactive waste.(8)

Text/ References	i) ediation and Natural Attenuation: Process fundamentals and mathematical models by P J J Alvarez and W A Illman, Wiley-Interscience water treatement: Concepts & design approach, G L Karia, R A Christian, PHI supply & waste water engineering, B S N Raju, Tata Mc Graw Hill Publications ial wastes, Their disposal & Treatment; Willem Rudolfs, Reinhold Publishing Corporation, American series icrobiology; N S Subba Rao; Oxford & IBH Publishing Co. Pvt Ltd. water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill nmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. & Greogia; PHI & wastewater Technology; Hammer, Mark J, Mark J Hammer; PHI radation & Bioremediation (1999), Martin Alexander, Academic press. Bioremediation engineering; design and application 1995 John. T. cookson, Jr. Mc Graw Hill, Inc. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., Environmental Pollution Control Microbiology by Ross E Mc Kinney, Dekker publisher Environmental Engineer's Mathematics Handbook by Frank R Spellman & Nancy E Whiting. CRC Publication Biology of wastewater treatment by N F Gray; Imperial College Press.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9048	**Protein structure, folding & misfolding**	PEL	3	0	0	3	3
Biochemistry, Cell Biology, Molecular Biology		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To learn about protein structures and its classification into structural groups. CO2: To understand protein-DNA interactions and the origin of selectivity and specificity in this process CO3: To learn how to determine protein structure CO4: Understanding of protein folding mechanism and how protein misfolding is related to several human diseases.						

Topics Covered	Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, fibrous proteins. (10) DNA structures. DNA recognition in prokaryotes by helix-turn-helix motifs. (6) DNA recognition by eukaryotic transcription factors, specific transcription factors. (6) Structural feature of common proteins involved in enzyme catalysis, signal transduction and immunity. (8) Protein Structure determination (4) Protein folding: thermodynamics, kinetics and chaperones. (4) Protein misfolding and Disease. (4)
Text Books, and/or reference material	Text Book: 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge Reference book: 1. Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht

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Course	Title of the course	Program Core	Total Number of contact hours				Credit
Code		(PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9049	**Methods in Computational Biology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Bioinformatics, C programming		CT+EA					
Course Outcomes	CO1: Learning computational skills to examine biological information CO2: Learning and developing computational tools for analysis of large biological data CO3: To understand the models of biological systems constructed from experimental measurements CO4: Learn about machine learning and statistical tools to construct models from large existing datasets						

Topics Covered	Algorithms in Computing: Biological and Computer algorithm, Fibonacci problem, Dynamic Programming, Time and space complexity of algorithms (7) Programming languages- Algorithm, Flowchart, Compiling, Testing and Debugging (7) C programming – C language Introduction, Identifier , Variables, Constants, Operators, Input statement, Output statement, Conditional and Unconditional Control Statement, Looping Statement: while, do-while, for loop, Arrays. Read, write files (biological data) (10) Clustering and Trees: Hierarchical Clustering, k-Means Clustering, Evolutionary Trees, Distance-Based Tree Reconstruction, Reconstructing Trees from Additive Matrices, Character-Based Tree Reconstruction, Small and large Parsimony Problem. (10) Hidden Markov Models: Markov processes and Markov Models, Hidden Markov Models (8)
Text Books, and/or reference material	Text Books: Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins" by A D Baxevanis and B F F Ouellette Protein Bioinformatics: An Algorithmic Approach to Sequence and Structure Analysis by Ingvar Eidhammer, Inge Jonassen, William R. Taylor Reference Books: Introduction to Computational Biology by Bernhard Haubold Bioinformatics: Genes, Proteins and Computers by Christine Orengo, David Jones, Janet Thornto

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9050	**Nano-biotechnology & Nanomaterials**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of biology, Chemistry and Physics		CT+EA					
Course Outcomes	CO1: Acquire advanced idea about nanoscale phenomenon CO2: To learn about the different investigation tools for the nanobiotechnology CO3: To learn about synthesis of diverse classes of nanomaterials CO4: To get comprehensive understanding of applications of nanotechnology in biology						

Topics Covered	Nanotechnology; introduction to miniaturization. (4) Investigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. investigation tools: nanoimprint lithography (8) Nanomaterials: organic and inorganic nanoparticles. (6) Molecular self-assembly and bottom up synthesis of nanomaterials. (6) Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6) Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6) Nanotoxicology. (4) Future Concepts in Nanobiotechnology. (2)
Text Books, and/or reference material	Text Book: 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. References Books 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9051	**Plant Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Cell Biology, Genetics, Molecular Biology & rDNA Technology		CT+EA					

Course Outcomes	CO1: To understand the concepts and techniques of plant tissue culture. CO2: To understand the basic methods of mapping and cloning plant genes. CO3: To learn the methodologies of genetic transformation of plants. CO4: To generate the ability to create genetically modified plants by means of plant breeding and genetic engineering with improved quality traits.
Topics Covered	History of Plant Tissue Culture (1) Lab requirements and general techniques (1) Tissue Culture Media (1) Hormones in plant tissue culture (4) Cellular Totipotency (1) Somatic embryogenesis (1) Cell Suspension Culture (1) Haploid Production, (1) Somaclonal variation (1) Protoplast Isolation and Culture (1) Micropropagation in plants(1) Morphological Markers, Biochemical Markers, (1) molecular markers (DNA / protein) – RFLP, RAPD,AFLP, SSLPs, ESTs, SNPs etc., (6) Molecular mapping, Map-based cloning, (2) marker-assisted selection, marker-aided breeding, (1) Cloning of plant genes using activation tagging, transposon tagging etc. (2) Direct and indirect methods of genetic transformation of plants, (2) *Agrobacterium* mediated gene transfer, Ti Plasmid, (3) vectors for plant transformation, selectable and screenable markers, (1) gene constructs, strategies for genetic transformation of plants,(2) gene silencing, RNA interference, (1) genome editing in plants, (1) resistance to biotic stresses, tolerance to abiotic stresses, genetically modified crops (5)
Text Books, and/or reference material	**Text Books:** H.S.Chawla, Introduction to Plant Biotechnology, Oxford &IBH Publishing co.Pvt..Ltd Slater.A.,NigelW.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. Bhojwani and Razdan –PlantTissue Culture: Theory and Practice 1996 Elsevier **Reference Books:** Butterworth & Heineman, Invitro Cultivation of Plant Cells, Biotol Series. H.E Street(ed): Tissue culture and Plant science, Academic press, London, 1974 GamborgO.L.,.Phillips G.C, Plant Cell, Tissue and Organ Culture, Narosa Publishing House

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9052	**Metabolic Engineering**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Basic concepts of chemical reaction kinetics & stoichiometry; matrices, Biochemistry, recombinant DNA Technology	CT+EA

Course Outcomes	**CO1:** To learn about the basic concepts of Metabolic Engineering **CO2:**To learn about the models of cellular reactions and to understand the regulation of metabolic pathways **CO3:** To understand the manipulation of metabolic pathways to enhance the yield and quality of the products **CO4:** To learn and understand the models and the concepts required for the purpose of metabolic flux analysis **CO 5:** To study the methods and application of metabolic flux analysis **CO 6:** To analyze metabolic networks
Topics Covered	Importance of metabolic engineering [1] Review of cellular metabolism, Regulation of metabolic pathways, Examples of pathway manipulations: metabolic engineering in practice – enhancement of product yield and productivity [10] Extension of product spectrum and novel products (antibiotics, biopolymers, polyketides, vitamins etc), Improvement of cellular properties [7] Metabolic modeling: Introduction to models for cellular reactions- stoichiometry, rates, and yield coefficients of cellular reactions, black box stoichiometries [7] Material balance & data consistency: Black box model; elemental balances, degree of reduction balances, Heat balance [7] Biochemical reaction networks: simple metabolic networks, flux analysis in metabolic networks; Metabolic control analysis [7] Xenobiotic degradation [3].
Text Books, and/or reference material	**Text Books:** Metabolic Engineering: Principles and Methodologies, Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, Academic Press Bioreaction Engineering Principles, Jens Nielsen, John Villadsen, Gunnar Liden, **Reference Books:** Pathway Analysis and Optimization in Metabolic Engineering, Néstor V. Torres, Eberhard O. Voit, Cambridge University Press An Introduction to Metabolic and Cellular Engineering, S. Cortassa, M. A. Aon , A. A. Iglesias, D. Lloyd, World Scientific Publishing Company

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9053	**Nutraceuticals & Nutrigenomics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To establish the correlation between nutraceuticals with cell signaling pathway. CO2: To target nutraceuticals from different sources. CO3: To understand the interaction between gut microbiota with functional food components and nutraceuticals. CO4: To formulate the concept of nutrient gene interaction.						
Topics Covered	Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals. Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics and transcription factors. Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds. Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in Nutrigenomics						
Text Books, and/or reference material	**Books** Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput, Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John Shi , CRC Press Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press						

	References: Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Hasler, Blackwell Publishing Professional

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9054	**Molecular Plant Pathogen Interactions**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Molecular Biology & rDNA Technology		CT+EA					
Course Outcomes	CO1: Development of basic concept of plant diseases and contribution of environment toward plant disease development. CO2: Understanding the genetics of plant pathogen interactions. CO3: Learning about mechanisms of host defense & pathogenesis. CO4: Development of knowledge toward developing control measures against phytopathogens.						
Topics Covered	Introduction to molecular plant pathology, Plant diseases, (4) Plant disease development and environment, (3) Effects of pathogen on plant physiology, (2) Biochemistry of plant defense reactions, (3) Plant-pathogen interactions, (3) Genetic regulation of resistance in host plants, (4) Genetic regulation of virulence in pathogen, (4) Mechanisms of host defense, (3) Mechanisms of pathogenesis, (3) Hormone signaling pathways, (7) Biotechnological approach for plant protection; (3) Genetically modified plants to protect against pathogens. (3)						

Text Books, and/or reference material	**Text Books:** Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. **Reference Books:** Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9055	**Cell Biology of Human Diseases**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Cell Biology, Molecular Biology and Biochemistry	CT+EA

Course Outcomes	CO1: To understand the concepts of structure, organization and molecular signaling of cells which govern its function. CO2: To understand cellular defects leading to human diseases and apply such understanding to explain any given phenotype at the cellular or organism level. CO3: To learn the application of experimental methods and designs to solve cell biology questions in human diseases.

Topics Covered	Overview of cell organizations and functions. (3) Experimentations in cell biology: Microscopy, genetic screens, cell fractionations and biochemical assays. (6) Cytoskeleton and extracellular matrix. Hypertrophic and dilated cardiomyopathies, epidermolysis bullosa simplex (EBS), muscular dystrophy, neurodegeneration, progeria, hearing defects. (4) Cell polarity, cell junctions and changes in cell shape. Neural Tube Defects.(2) Cell transport, endocytosis, exocytosis, membrane channels. Cholera and cystic fibrosis. (3) Cell migration during development and chemotaxis. Developmental defects and cancer.(1) Cilia structure and function and specialized sensory cells. Ciliopathies.(1) Protein processing, trafficking and transport. Microbial immune evasion,lysosomal storage disease, and diabetes.(4) Neurons, astrocytes and oligodendrocytes. Demyelinating diseases.(1) Mitochondrial function and mitochondrial genome. Mitochondrial diseases.(2) Cell cycle, cell proliferation, apoptosis. Cancer.(4) Stem cells and cell differentiation. Cancer.Regenerative medicine. (3) Nuclear organization and gene expression.Cancer.(2) Paper presentations (in group).(4)
Text Books, and/or reference material	Text Books: Molecular Biology of the Cellby Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.6th Edition, 2014.Garland Science. Reference Books: Molecular Cell Biologyby Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, HiddePloegh, Paul Matsudaira. 8th edition, 2016. Publisher: WH Freeman. . Cell and Molecular Biology: Concepts and Experiments by Gerald Karp. 6th Edition, 2010. Wiley.

			Department of Biotechnology				
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9056	**Infectious Diseases & Infection Control**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Immunology		CT+EA					

Course Outcomes	CO1: To understand about the spread of infectious diseases, the social impact and means of infection control CO2: To learn about bacterial infections and ways to tackle different bacterial diseases CO3: To learn the viral infections, vaccine development and challenges CO4: To learn about the protozoan and fungal infections and methods to combat them
Topics Covered	Origin of Infection; Evolution of infectious diseases; Concept of Infection: Immunity, Immune surveillance, Virulence, Pathogenesis (4) Introduction to pathogenic and non-pathogenic bacteria; Common bacterial diseases in humans; Basic mechanism of Bacterial pathogenesis; Bacterial survival in host cells- Quorum sensing; Bacterial virulence factors: Microbial structures and Toxins; infection; Bacterial immune evasion: Molecular Mimicry; Strategies for antibacterial therapy: Antibiotics, Other antibacterial compounds, and Antibiotic resistance- MDR and XDR strains. Bacterial vaccines. Case study: *E. coli* infection and diarrhoea (9) History of viral infections; Different viral diseases; Viral pathogenesis; Viral life cycle; Virus genomes and structure; Host –virus interactions; Host Immune reaction against viruses; Viral evasion of host immune surveillance; Antiviral pathways; Mutations in viral genome; Viral diseases and antibody response; Vaccine against viral diseases; Antivirals compounds for viral infections; Challenges in vaccine production against certain virtues; Case study: Influenza (9) Introduction to Protozoan Diseases; Different protozoan diseases, General mode of action of protozoa; Pathogenesis of protozoan diseases; Host response to Protozoans; Molecular signalling against Protozoa; Hypersensitivity and autoimmunity associated with Protozoan infections; Antimalarial drug development ; Case study: Plasmodium (7) General fungal diseases; Mode of action of fungal diseases; Immune response against fungal infection; Case study: Candidiasis; Infection caused by Yeast; Mode of action of Yeast infection; Case study: Ring worm (4) ; Infection and life style-Concepts of Microbiome; Neglected diseases (2) Spread of Infectious diseases; Disease epidemiology, Steps involved in epidemiology and epidemiological case studies; (3) Purpose of infection control, Regulations, policy and practice; Roles and responsibilities in infection control; Risk assessments; Principles of infection control procedures (4).
Text Books, and/or reference material	Text Books: 1. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases- 8thEdition; Volume I and II. By John E. Bennett , Raphael Dolin, Martin J. Blaser. SaudersPublication. 2. Immunology of Infectious Diseases. Edited By Stephan Kaufmann, Alan Sher, and Rafi Ahmed. American Society for Microbiology.

	Reference Books: 1. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. American Society for Microbiology 2. Practical Healthcare Epidemiology, 4th Edition. By Ebbing Lautenbach. Cambridge University press. 3. Principles and practice of clinical bacteriology-2nd Edition. By Stephen Gillespie, Peter M. Hawkey. John Wiley &Sons.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9057	**Project Engineering in Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	CO1: Learning about process flow diagram and basic concepts of plant design CO2: Learning about cleaning of process equipment and design of pipes and valves CO3: Learning about facility design and project planning CO4Learning about Planning, construction and commissioning of a biopharmaceutical manufacturing plant CO5: Learning about process economics CO6: Learning about production concepts						

Topics Covered	Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments & their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods (6) Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and clean ability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. (5) Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) (4) Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. (4) Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. (6) Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. (6) Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. (5) Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of
	manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. (6)
Text Books, and/or reference material	Text Books: Bioprocess engineering: system, equipment and facilities, B K Lydersen, N AD'Elia, K M Nelson. Wiley Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley Reference Books: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9058	**Biological Computation**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Cell Biology, Biochemistry, Programming and Data Structure	CT+EA
Course Outcomes	CO1: Learning about different biological databases and the biological data stored in them CO2: To learn UNIX operating system to run bioinformatics resources CO3: To acquire knowledge of Bash scripting and programming skills for analyzing biological data CO4: To learn how to store and visualize biological data using computational methods
Topics Covered	**Biological data and different file formats:** Introduction to biological databases, sources of biological data, genbank, fasta file formats, interchanging of file formats (3) **Introduction to Linux operating system:** What is Linux OS, Kernel system, benefits of Linux for computational biology (3) **Bash programming for bioinformatics:** Shell scripting, working in terminal with different commands, use of important commands such as sed, grep, awk (8) **C programming for bioinformatics:** introduction to C, Identifier , Variables, Constants, Operators, Input statement, Output statement, Conditional and Unconditional Control Statement, Looping Statement: while, do-while, for loop, Arrays. Read, write files (biological data) (10) **Python scripting for bioinformatics:** File handling in python, numpy, pandas etc (8) **Database management:** Designing databases using SQL (5) **HTML and web-designing:** Designing web-pages using HTML and java scripts (5)
Text Books, and/or reference material	Text Books: Computational Biology —Unix/Linux, Data Processing and Programming by Röbbe Wünschiers Learning Python, 5th Edition by Mark Lu
	Reference Books: Introduction to Bioinformatics by Arthur M Lesk Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9059	**Quality by Design for Biopharmaceuticals**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	CO1: Learning about the concept of QbD and importance in Biotechnology CO2: Learning about QbD for Biopharma production process CO3: Learning about QbD for Biopharma purification process CO4: Learning about QbD in biologics formulation and product development CO5: Learning about PAT tools CO6: Learning about integration of PAT with QbD						
Topics Covered	1. QbD: Basic Concepts (2) 2. Considerations for Biotech Product QbD (3) 3. Risk Assessment to determine criticality of product quality attributes (3) 4. Case study on definition of process design space for a microbial fermentation step (4) 5. Application of QbD for Tangential Flow Filtrationprocess (4) 6. Applications of design space for biopharmaceutical purification processes (4) 7. Viral Clearance: A Strategy for QbD and the design Space (4) 8. Application of Quality by Design and risk assessment principles for the development of formulation design space (4) 9. Application of QbD principles to biologics product: formulation and process development (4) 10. QbD for Raw Materials (2) 11. PAT Tools for Biologics (4) 12. Evolution and Integration of QbD and PAT (4)						
Text Books, and/or reference material	Text Books: Anurag S Rathore, 2009, Quality by Design for Biopharmaceuticals: Principles and Case Studies, Wiley.						

Department of Biotechnology								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9060	**Medical Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Immunology, Molecular Biology, rDNA technology		CT+EA					
Course Outcomes	CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence. CO2: Able to analyze the key features therapeutics and drugs in current scenario. CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals. CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.						
Topics Covered	Module 1: Biochemical diagnostics in Medical Biotechnology 10 Clinical diagnosis of diseases: Inborn errors of metabolism and genetic disorders. Preimplantation diagnosis, pre-natal diagnosis-chorionic villus sampling, Amniocentesis. Molecular techniques for analysis of diseases: DNA polymorphism; 'disease' gene vs. 'susceptibility' gene; SNP detection: hybridization based assays; Polymerization based assays; Ligation based assays; Polymorphism detection without sequence information: Single nucleotide polymorphism and disease association; High throughput DNA sequencing and diagnosis; and Array based techniques in diagnosis. Module 2: Drug Discovery and targeting: 10 Overview of inherited and acquired diseases for gene therapy; Identification of disease biomarkers and selection of drug targets; Proteomics and High throughput DNA screening for drug discovery; Gene silencing technology: therapeutic applications in treatment of influenza and HIV/AIDS; Tissue and organ transplantation; Transgenics and their uses. Delivery system development: Intracellular barriers to gene delivery; virus, Liposome and nanoparticles mediated gene delivery. Module 3: Production of pharmaceuticals: 12 Production of pharmaceuticals by genetically engineered cells. Microbial transformation for production of important pharmaceuticals. Techniques for development of new generation antibiotics; Pharmacogenomics and pharmacogenetics of pharmaceuticals; Cellular and genotoxicity of pharmaceuticals.						

	Module 4:Clinical research: 10 Introduction and importance of clinical research, Drug development and phases of clinical trials: Designing clinical trials, Protocol designing, Ethical, safety and regulatory issues in clinical research, Drug regulatory concepts and accrediting agencies of the world (USFDA, TGA, ICH, WHO, ISO etc.), ICH-GCP Guidelines, Informed consent process, Role of CRC and CRA in clinical trials, Standard operating procedures, Guidelines to undertake clinical trials in India.
Text Books, and/or reference material	**Books** Lewis, Human Genetics, 7th Edition, WCB & McGraw, 2007. Maroni, Molecular and Genetic Analysis of Human Traits, 1st Edition, Wiley-Blackwell, 2001. Alberts et al, Molecular Biology of The Cell, 2nd Edition , Garland 2007 Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford Reference: Pharmaceutical Biotechnology ; Sambhamurthy & Kar , New Age Publishers Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

			Department of Biotechnology				
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9061	**Biological Chemistry**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of biology, chemistry and physics		CT+EA					

Course Outcomes	CO1: Understanding of the basic thermodynamic and kinetic aspect of biology. CO2: Getting familiarity with common principle of chemistry and chemical bonds CO3: To have a deeper understanding of energy flow in biology. CO4:To learn about the chemical reactions relevant to biological processes.
Topics Covered	Chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant). (8) Chemical and Biological Synthesis-Introduction to synthesis in biology. Chemical synthesis of peptides and proteins. Chemical synthesis of nucleic acids. Chemical synthesis of oligosaccharides. Chemical synthesis of lipids. Biological synthesis of biological macromolecules. Directed biological synthesis of proteins. Biological synthesis of nucleic acids, oligosaccharides and lipids. (6)
	Advance chemical and physical tools for Biology-Electronic and vibrational spectroscopy in biology, Circular dichroism spectroscopy, Vibrational spectroscopy, Fluorescence spectroscopy, X-ray crystallography, Mass spectrometry for proteomics. (8) Chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation- reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes. (8) Bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot). Types of organic reactions in biology; addition reactions- electrophilic, nucleophilic and free radical. Substitution reactions – electrophilic, nucleophilic and free radical. Elimination and Rearrangement reactions; Chemical insight of enzyme catalyzed reactions – proteases, polymerases, ribosomes. (12)
Text Books, and/or reference material	Text Book: 1. Ebbing, D. D., &Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin. 2. Averill, B., &Eldredge, P. (2007). Chemistry: Principles, Patterns, and Applications. San Francisco: Benjamin Cummings. 3. Cantor, C. R., &Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9062	**Bioentrepreneurship**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Basic understanding of Biosafety guidelines	CT+EA

Course Outcomes	**CO1.** To educate about various societal, governance and regulatory issues in biotechnology. **CO 2**. To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey. **CO 3**. To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products. **CO 4.** To raise awareness about the ethical implications and safety rules in biopharma and GMO production management.
Topics Covered	**Introduction to Bioentrepreneurship**: Fundamentals of Marketing of biotechnological products, patent rules regarding product licensing. (4)
	Entrepreneurship traits & motivation: Growth of entrepreneurship, The marketing and selling of Biotechnology, Creating and marketing the image of the biotechnology company, Effective advertising and marketing.(8) **Entrepreneurial development:** Training, institution in aid of entrepreneur, Power and importance of Positioning of a company name and product. (6) **Capacity building**: **Regulatory systems for health products in India**: Regulatory authority India central (federal) and state (provincial) authorities. Central Licensing Authority. International collaboration of India with South East Asia Regulatory Network (SEARN). Quality management system (QMS). Regulatory functions : Control of clinical trials. Marketing Authorization, Registration Certificate for Import, Manufacturing Licence, Non-Objection Certification (NOC). Licence to manufacture Pre-approval batches, Import Licence, Export NOC for Biological Samples Pharmacovigilance for medicines, vaccines and blood products. (3) Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, Workable marketing and the strength of distribution. Opportunities in international marketing. (8)

	Risk & benefit assessment: Steps involved in product licensing and technology transfer for commercialization of a biotechnological product. (6) **Ethical issues and Biosafety guidelines:** Food safety and environmental safety evaluation of genetically modified microbes, crops, animals (GMO & LMOs); Roles of Institutional Biosafety Committee, WHO, DBT guideline for institutional biosafety . Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms. Ethical implications of biotechnological products and techniques over human health. (7)
Text Books, and/or reference material	Text Book: 1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay Publications. 2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication. 3. Entrepreneurship development in India; Samiuddin, Mittal Publication References: • Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market • Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006. • Design and Marketing of New Products by Urban and Hauser,ISBN 0-13-201567-6 • Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences The national academy press

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY / DUAL DEGREE / INTEGRATED M.Sc PROGRAM

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in ______ Senate # _______________ # Item no: _______

DEPARTMENT OF CHEMICAL ENGINEERING

Program Name: Bachelor of Technology and Master of Technology (Dual Degree) in Chemical Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR CHEMICAL ENGINEERING - B.TECH. AND M.TECH (DUAL DEGREE)

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CHC301	Process Calculations	3	1	0	4.0	4
3	CHC302	Chemical Engineering Thermodynamics	3	1	0	4.0	4
4	CHC303	Fluid Mechanics	3	1	0	4.0	4
5	CYC331	Chemistry - II	3	0	0	3.0	3
6	CYS381	Chemistry Laboratory- II	0	0	3	1.5	3
7	CHS351	Chemical Engineering Computing Laboratory- I	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CHC401	Heat Transfer	3	1	0	4.0	4
2	CHC402	Mechanical Operation	3	1	0	4.0	4
3	CHC403	Mass Transfer- I	3	1	0	4.0	4
4	MEC432	Mechanical Design of Equipment and Components	3	0	0	3.0	3
5	YYO44*	Open Elective - I	3	0	0	3.0	3
6	CHS451	Fluid Mechanics Laboratory	0	0	3	1.5	3
7	CHS452	Process Equipment Design- I Sessional	0	0	3	1.5	3
8	WSS481	Workshop Practice- II	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CHC501	Chemical Reaction Engineering	3	1	0	4.0	4
2	CHC502	Mass Transfer- II	3	1	0	4.0	4
3	CHC503	Chemical Process Technology	3	1	0	4.0	4
4	CHC504	Process Control and Instrumentation	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	CHS551	Heat Transfer Laboratory	0	0	3	1.5	3
7	CHS552	Mechanical Operations Laboratory	0	0	3	1.5	3
8	CHS553	Process Equipment Design- II Sessional	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	15	4	9	23.5	28

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	CHC601	Transport Phenomena	3	1	0	4.0	4
3	CHC602	Petroleum Refining and Petrochemicals	3	1	0	4.0	4
4	CHC603	Process Modelling and Simulation	3	0	0	3.0	3
5	CHE610 --	Depth Elective - 1	3	0	0	3.0	3
6	CHS651	Fuel Laboratory	0	0	3	1.5	3
7	CHS652	Reaction Engineering Laboratory	0	0	3	1.5	3
8	CHS653	Mass Transfer Laboratory	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	2	9	21.5	26

Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	CHE710 --	Depth Elective - 2	3	0	0	3.0	3
3	CHE710 --	Depth Elective - 3	3	0	0	3.0	3
4	CHE710 --	Depth Elective - 4	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	CH1003	Advanced Mathematical Methods for Chemical Engineering	3	1	0	4.0	4
7	CHS751	Process Control and Instrumentation Laboratory	0	0	3	1.5	3
8	CHS752	Chemical Engineering Computing Laboratory-II	0	0	3	1.5	3
9	CHS753	Computer Aided Process Equipment Design Laboratory	0	0	3	1.5	3
10	CHS754	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
		TOTAL	18	1	11	24.5	30

Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CH2001	Advanced Chemical Engineering Thermodynamics	3	1	0	4.0	4
2	CH2002	Advanced Transport Phenomena	3	1	0	4.0	4
3	CHE810 --	Depth Elective - 5	3	0	0	3.0	3
4	CH903*	Depth Elective - 6	3	0	0	3.0	3
5	YYO84*	Open Elective - 4	3	0	0	3.0	3
6	YYO85*	Open Elective - 5	3	0	0	3.0	3
7	CHS854	Minor Project	0	0	12	4.0	12
		TOTAL	18	2	12	24.0	32

Semester - IX							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CH1002	Chemical Reactor Analysis and Design	3	1	0	4.0	4
2	CH903*	Depth Elective - 7	3	0	0	3.0	3
3	CH3071	Major Project - I	0	0	24	12.0	24
4	CH3072	Major Project Seminar – I	0	0	0	2.0	0
		TOTAL	6	1	24	21.0	31
Semester - X							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CH4051	Major Project - II	0	0	24	12.0	24
2	CH4052	Major Project Seminar – II and Viva Voce	0	0	0	2.0	0
3	CH4053	Grand Viva Voce	0	0	0	1.0	0
		TOTAL	4	0	24	15.0	24

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	IX	X	TOTAL
Credit Unit	**45.0**	**22.0**	**22.5**	**23.5**	**21.5**	**24.5**	**24.0**	**21.0**	**15.0**	**219.0**

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CHE610	Chemical Reactor Analysis
CHE611	Industrial Pollution Control and Treatment
CHE612	Non-conventional Energy Engineering
CHE613	Combustion Engineering
CHE614	Artificial Intelligence in Chemical Industries

7th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CHE710	Energy Sources & Utilization
CHE711	Bioprocess and Bioreactor Engineering
CHE712	Process Engineering
CHE713	Chemical Plant Design and Economics
CHE714	Process Safety in Chemical Industries

CHE715	Membrane Separation Processes
CHE716	Process Intensification
CHE717	Colloids and Interface Engineering
CHE718	Pinch Technology
CHE719	Energy Management and Process Optimization in Chemical Industry
CHE720	Self-Mastery

8th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CHE810	Multiphase Flow
CHE811	Process Analysis and Optimisation
CHE812	Boiling Heat Transfer
CHE813	CFD Applications in Chemical Engineering
CHE814	Nanotechnology

9th Semester

	DEPARTMENT OF CHEMICAL ENGINEERING
CH9011	Biochemical and Bio Engineering
CH9012	Advanced Process Dynamics and Control
CH9013	Environmental Engineering
CH9014	Non-conventional Energy Engineering
CH9015	Chemical Process Optimization
CH9016	Multiphase Flow
CH9018	Petroleum Refining and Petrochemical Engineering
CH9020	Mathematical Heat Transfer and Fluid Flow
CH9021	Ethics in Engineering Profession
CH9023	CFD Applications in Chemical Engineering
CH9026	Nanotechnology
CH9027	Computer Aided Process Engineering
CH9028	Advanced Water and Wastewater Technology
CH9030	Colloids and Interface Engineering
CH 9034	Pinch Technology in Process Industry
CH 9042	Membrane Technology in Environmental Pollution Control
CH 9043	Biofuel Technology

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I								
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points,						

	Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course	CO1: To realize and apply the fundamental concepts of physics such as superposition						

Outcomes	principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes

- CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications
- CO2: To learn fundamentals of polymer chemistry and petroleum engineering.
- CO3: Introduced to basic spectroscopic techniques for structure determination and characterization.
- CO4: To study few inorganic and bioinorganic compounds of industrial importance.

Topics Covered

ORGANIC CHEMISTRY

i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3)

ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3)

iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2)

iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)

v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3)

INORGANIC CHEMISTRY

i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5)

	ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)[#]	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA

Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5^{th} Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5^{th} Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)[#]	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1^{st}, 2^{nd}, 3^{rd} and 4^{th} quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	Professional Communication Lab	PCR	1	0	2	3	2

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes

- CO1: Improvement in linguistic proficiency of the learners
- CO2: Improvement in communicative ability of the learners
- CO3: Improvement in social connectivity skill

Topics Covered

1. Professional Communication: Introduction (1)
2. Technical Writing: Basic Concepts (2)
3. Style in Technical Writing (3)
4. Technical Report (2)
5. Recommendation Report (2)
6. Progress Report (1)
7. Technical Proposal (3)
8. Business Letters (3)
9. Letters of Job Application (2)
10. Writing Scientific and Engineering Papers (3)
11. Effective Use of Graphic Aids (2)
12. Presentation Techniques (6)
13. Group Discussion (6)
14. Interview Techniques (6)

Text Books, and/or reference material

Text Book:
1. English for Engineers –Sudharshana& Savitha (Cambridge UP)

Reference Books:
1. English for Engineers -Sudharshana & Savitha (Cambridge UP)
2. Effective Technical Communication-M A Rizvi (McGraw Hill Education)
3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes

- CO1: To learn basic analytical techniques useful for engg applications.
- CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance.
- CO3: Learn chromatographic separation methods.
- CO4: Applications of spectroscopic measurements.

Topics Covered

i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter.
ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH.
iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry
iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration.
v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc.
vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone.
vii. Synthesis of polymer: polymethylmethacrylate
viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution.
ix. Chromatography: Separation of two amino acids by paper chromatography
x. Determination of saponification value of fat/ vegetable oil

Suggested Text Books:
1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall
2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu
3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra

Suggested Reference Books:
1. Practical Chemistry By R.C. Bhattacharya
2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	WORKSHOP PRACTICE	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Study and practice on machine tools and their operations • CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding • CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping • CO4: Develop basic electrical engineering knowledge for house wiring practice
Topics Covered	**M/c shop & Carpentry shop -- 3X3= 9hrs.** • Introduction on machining process. • Introduction to machine tools- Lathe, Shaper, Milling and Drill machine. • Introduction to woods- Types, structure, disease and defect of wood. • Introduction to wood working machines and tools. • Making of dovetail joint and bridle joint. **Welding Shop & Sheet metal -- 3X3= 9hrs.** • Introduction to welding.Safety and precautions in welding. • Formation of weld bead by SMAW on mild steel flat. • Formation of weld bead by oxy-fuel welding on mild steel flat. • Introduction to sheet Metal works. • Tools and Machines used in sheet metal works. • Concept of development, marking out of metal sheets. • Cutting and joining of metal sheets. • Safety precautions, General warning needed in the shop floor. **Black smithy & Foundry -- 3X3= 9hrs.** • Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels. • Safety and precautions in blacksmithy. • Making of bars of different cross-sections. • Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology. • Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution.

	• Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	Co-curricular Activities	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra,						

	Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket

	• Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS**

	• Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					
Course Outcomes	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.						
Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)						

	Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian
	determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4) **Laplace and Fourier Transforms:** Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10^{th}ed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3^{rd} Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's						

	(operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic Electronics**	PCR	2	1	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	• CO1: Knowledge of Semiconductor physics and devices. • CO2: Have an in depth understanding of basic electronic circuit, construction, operation. • CO3: Ability to make proper designs using these circuit elements for different applications. • CO4: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	1. **Semiconductors** 1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium 1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons 1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction						

	2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741,

	9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	ELECTRICAL TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))					
NIL		CT+MT+ EA					
Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts. • CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's • CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts. • CO4: introduce the basic concept of single-phase transformer. • CO5: analyze the transient phenomena in electrical circuits with DC excitation.						
Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)						

Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications

	Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy,

	favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour)						

	8. Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18^{th} ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25^{th} ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECS 51</td><td>Basic electronics Lab</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire idea about basic electronic components, identification, and behavior.
• CO2: To determine IV characteristics of these Circuit elements for different applications.
• CO3: Learn to analyze the circuits and observe and relate input and output signals.</td></tr>
<tr><td>Labs Conducted.</td><td colspan="7">1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments.
2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it.
3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms.
4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.
5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs
6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs
7. Transistor as a Switch: study and perform transistor as a switch through NOT gate
8. Zenner diode as voltage regulator
9. To study clipping and Clamping circuits
10. To study different biasing cirtis.
11. Study of CE amplifier and observe its frequency response.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al.
<u>Reference Books</u>:
1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill
2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td>ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: understand the principle of superposition.
• CO2: understand the principle of maximum power transfer
• CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp.
• CO4: understand the calibration of energy meter.
• CO5: understand open circuit and short circuit test of single-phase transformer.
• CO6: analyze RLC series and parallel circuits
• CO7: understand three phase connections.
• C08: understand determination of B-H curve</td></tr>
<tr><td>Topics Covered</td><td colspan="7">List of Experiments:
1. To verify Superposition and Thevenin's Theorem.
2. To verify Norton and Maximum power transfer theorem
3. Characteristics of fluorescent and compact fluorescent lamp
4. Calibration on energy meter
5. To perform the open circuit and short circuit test on single phase transformer
6. To study the balanced three phase system for star and delta connected load
7. Characteristics of different types of Incandescent lamps
8. Study of Series and parallel R-L-C circuit
9. Determination of B-H Curve for magnetic material</td></tr>
<tr><td>Textbooks, and/or reference material</td><td colspan="7">Textbooks:
1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma , H U Ezea
2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3

CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL**						

	• Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block. • Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.

- Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin.
- Service: Backhand/Forehand- Push service, Deep push service, Rally service.
- Service: Backhand sidespin (Left to right & Right to left).
- Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service.
- Rules and their interpretations.
- Table Tennis Match (Singles & Doubles).

NCC

- FD-6 Side pace, Pace Forward and to the Rear.
- FD-7 Turning on the March and Wheeling.
- FD-8 Saluting on the March.
- FD-9 Marking time, Forward March and Halt in Quick Time.
- FD-10 Changing step.
- FD-11 Formation of Squad and Squad Drill.
- FD-12 Parade practice.

TAEKWONDO

- Poomsae (Forms)- Jang, Yi Jang.
- Self Defense Technique- Self defense from arms, Fist and Punch.
- Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring).
- Combination Technique- Combined kick and punch.
- Board Breaking (Kyokpa)- Sheet breaking.
- Interpretation Rules above Technique of Taekwondo.

NSS

- No Smoking Campaign
- Anti- Terrorism Day Celebration
- Any other observation/celebration proposed by Ministry/institute
- Public Speaking
- Discussion on Current Affairs
- Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CO-PO Mapping and Matrix

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

MAC0 1	CO1	3	3	1	2	-	-	-	-	1	-	-	-
	CO2	3	3	1	2	-	-	-	-	1	-	-	-
	CO3	3	3	1	2	-	-	-	-	1	-	1	1
	CO4	3	-	-	2	-	2	-	-	1	-	-	-
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1
CYC01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-
MAC0 2	CO1	2	3	1	3	-	-	-	-	2	-	-	-
	CO2	2	3	1	2	-	-	-	-	2	-	-	-
	CO3	2	2	2	3	2	-	-	-	3	-	1	1
	CO4	2	3	2	3	2	1	1	-	2	-	-	-
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-

	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-
ECC01	CO1	-	-	-	-	-	-	-	-	-	-	-	-
	CO2	-	-	-	-	-	-	-	-	-	-	-	-
	CO3												
	CO4	-	-	-	-	-	-	-	-	-	-	-	-
EEC01	CO1	3	1	-	-	2	-	-	-	-	1	-	-
	CO2	2	3	2	-	2	-	-	-	-	-	-	-
	CO3	2	3	1	-	-	-	-	-	-	1	-	-
	CO4	3	1	2	-	1	-	-	-	-	-	-	-
	CO5	3	1	2	-	1	-	-	-	-	-	-	-
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-
EES51	CO1	3	-	2	-	3	-	-	-	1	-	-	-
	CO2	3	-	2	-	3	-	-	-	1	-	-	-
	CO3	2	3	2	2	1	-	2	-	1	-	-	-
	CO4	2	3	1	2	2	-	1	-	1	1	-	-
	CO5	2	3	1	2	2	-	-	-	1	-	-	-
	CO6	2	3	2	2	2	-	-	-	1	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-

	CO5	-	-	-	-	-	3	1	-	-	-	-	-

THIRD SEMESTER

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC331	**MATHEMATICS-III**	PCR	3	1	0	4	4
Pre-requisites		Basic knowledge of topics included in MAC01 & MAC02					

Course Outcomes	• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering. • CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems. • CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts. • CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.
Topics Covered	**Module - I** **Partial Differential Equations (PDE):** Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14 hrs] **Module - II** **Numerical Methods:** Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations.[14 hrs] **Module - III** **Complex Analysis:** Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17 hrs.] **Module - VI** **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [11 hrs.]

Text Books, and/or reference material	Suggested Text Books: 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar& R.K. Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig Suggested Reference Books: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
MAC 331	CO1	3	3	3	2	2	1	2	-	-	-	-	2
	CO2	3	3	2	2	2	1	2	-	-	-	1	2
	CO3	3	3	2	2	3	-	1	-	-	1	-	2
	CO4	3	2	2	3	2	1	1	-	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC301	**PROCESS CALCULATIONS**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (CT) and End Sem Assessment (EA)					
Nil		CT+EA					
Course Outcomes	• CO1: Learn fundamentals of units and dimension, dimensionless groups and their implications. • CO2:Graphical interpretation of experimental data, use of log-log and semi log plots for non-linear equations • CO3:Understanding of mass and energy balance for various chemical processes • CO4:Understanding the Ideal gas equation, Raoult's law, Henry's law, and psychrometric property						
Topics Covered	**Module - I** Units and dimension, Dimensionless groups and their significance, Dimensional homogeneity and analysis: Buckingham's pi theorem and its application, repeating variables, Rayleigh methods, Stepwise methodology Adiabatic Flame Temperature and its importance, Energy balance in thermal reactor, Computation of AFT, effect of temperature and pressure Basic understanding of application of semi-log and log-log graph, Unit operation						

	and experimental data fittings in log-log and semi-log graph paper, Problem-solving techniques [9 hrs.] **Module - II** Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial volume, Dalton's law and Amagat's law and Numerical problems on their applications Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications, Numerical problems on Duhring& Cox plots. Ideal& non-ideal solutions, Raoult's law, Henry's law and their applications in numerical problems. [8 hrs.] **Module - III** Concept of Material balance, basis of calculation, bypass and recycling operation, various problems on material balance- drying, evaporation, crystallization, leaching. Material balance with chemical reaction. Atmospheric air and its composition, the property of moist air and ideal gas law, Humidity and its significance, various humidity/saturation terms like molar, absolute, relative & percentage saturation Fundamental concept of dry-bulb, wet-bulb, adiabatic saturation temperatures, and dew point. Psychometric/humidity chart and its application Humid volume, enthalpy and specific heat of moist air, humidification and de-humidification operation and material balance. Theoretical analysis and Energy balance during adiabatic saturation and wet bulb temperature [13 hrs.] **Module - IV** Energy conservation laws, Energy balance, Laws of thermodynamics with examples, Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, Estimation of Heat Capacities: liquids and gases. Heat of fusion and vaporization. Enthalpy calculation for systems with Chemical Reaction, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Kopps rule Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Application of Energy balance to problems of various chemical processes [12 hrs.] ● **Tutorial on above topics and class tests (14)**
Text Books, and/or reference material	Suggested Text Books: 1. Basic Principles and Calculations in Chemical Engineering – David Himmelblau, PHI Suggested Reference Books: 1. Chemical Process Principles – Hougen and Watson, Part-I, CRC Press, CBS. 2. Stoichiometry-4thedn, Bhatt and Vora, Tata Mc-Graw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3		3						3	

CO2	3		3		3						3	
CO3	3	3			3							
CO4	2	2	2		2			3	3	3	2	

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Chemical Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC302</td><td colspan="2">CHEMICAL ENGINEERING THERMODYNAMICS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">●CO1: Apply the laws of thermodynamics to chemical engineering processes and conversion devices.
●CO2: Calculate thermodynamic properties using equations of state, charts and tables.
●CO3: Apply the concept of phase equilibrium to multi-phase systems.
●CO4: Solve problems of single and multi-phase chemically reactive systems using the concept of chemical reaction equilibrium.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Module – I
Scope of thermodynamics and fundamental concepts. Microscopic and microscopic view. First law of thermodynamics: Applications to batch and flow systems.
Second and third law of thermodynamics: Reversibility and irreversibility, Carnot cycle, entropy, free energies, exergy [5 hrs.]

Module – II
Real gases: Equations of state, compressibility charts, departure functions
Thermodynamics of flow processes: Single and multi-stage compression, expansion through nozzles.
Refrigeration and liquefaction of gases: Vapour compression, cascade, absorption and gas refrigeration cycles, Choice of refrigerants, Linde and Claude processes of liquefaction of gases. [9 hrs.]

Module – III
Thermodynamic property relations: Maxwell's relations and thermodynamic functions of pure substances. Residual properties, fugacity. [5 hrs.]</td></tr>
</table>

	Module – IV Solution thermodynamics and phase equilibrium: Multi-component gaseous systems and solution. Partial molal properties and thermodynamic potential, criteria for equilibrium, thermodynamic properties of solutions, Gibbs-Duhem equation and consistency of thermodynamic data. Activity and activity coefficient, estimation of activity coefficient- Margules and Van laar equations, ASOG and UNIFAC methods. Generation of VLE data. Calculation of bubble and dew points of ideal and non-ideal solutions. Azeotropes. Systems. Phase equilibrium at elevated pressure. [12hrs.] **Module – V** Chemical reaction equilibrium: Estimation of equilibrium constant. Homogeneous reactions. Heterogeneous reactions. [9hrs.] Tutorial on above topics and class tests. [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill) 2. Chemical Engineering Thermodynamics – G. N. Halder (Prentice Hall of India) SuggestedReference Book: 1. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley) 3. Applications of Thermodynamics, V. Kadambi , T. R. Seetharam, K. B. Subramanya Kumar, Wiley (2019)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Pos Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC303	**FLUID MECHANICS**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods [Continuous (CT) and end assessment (EA)]					

Nil		CT+EA
Course Outcomes	• CO1: Createafundamental understanding of fluidstatistics kinematicsandkinetics • CO2: Apply mass,momentumandenergy balance to hydrostatic and fluid flow problems • CO3: Acquire knowledge of Fluid machineries and flow measuring devices	
Topics Covered	**Module - I** Fluids and fluid properties, continuum concept, Fluid statics: Pressure and pressure measuring devices, Fluid kinematics, different flow regimes, equation of continuity. Boundary layer, Skin and form friction. [6 hrs.] **Module - II** Bernoulli's equation, Hagen-Poiseuille equation, Fanning's equation and their applications Pipes, fittings and valves. Pressure losses due to sudden expansion, contraction and fittings Navier-Stoke's equation and total energy balance equation Turbulent flow, Reynold's stress, universal velocity profile [16 hrs.] **Module - III** Flow past solid surface, drag, flow through packed bed, fluidization, pneumatic conveying Flow of compressible fluids, flow through convergent-divergent nozzles Non-Newtonian fluids: Their characteristics and calculation of pressure drop due to their flow through pipes Flow measuring devices: Orificemeter, venturimeter, rotameter, weirs, anemometer, pitot tubes, etc. [11hrs.] **Module - IV** Fluid machineries: Pumps, blowers and compressors [10hrs.] Tutorial on above topics and class tests [14 hrs.]	
Text Books, and/or reference material	Suggested Text Books: 1. Unit Operations – McCabe W L and Smith J L (McGraw Hill) 2. Transport Processes and Unit Operations – GeankoplisJ G, Allen A H, Lepek D H (Prentice Hall) Suggested Reference Books: 1. Principle of Unit Operations – Foust A S, Wenzel L A, Curtis W, Maus L, Anderson L B (Wiley)	

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemistry								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 331	**CHEMISTRY - II**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Engineering Chemistry CYC 01		CT+MT+EA					
Course Outcomes	• CO1: To learn advanced analytical techniques useful for chemical engineering. • CO2: To learn the few catalytic process commonly used in industrial applications. • CO3: To learn thermodynamics of solutions and understanding of phase diagrams of single and multicomponent systems. • CO4: To learn fundamentals of fats, oils and carbohydrate chemistry together with basics of large scale organic synthesis.						
Topics Covered	**Module - I** Organic Chemistry Organic C-C bond formation: application of Grignard reagents, ethyl acetoacetate and malonic esters. Principles of large scale organic synthesis having industrial importance. Carbohydrate chemistry: Classification, structure elucidation. Reactions of glucose and fructose; mutarotation, inversion of cane sugar. Fats and oils, soaps and detergents.[11 hrs.] **Module - II** Inorganic Chemistry Application of coordination compound in analytical chemistry: complexometric titration, biological application. Analytical methods used to metal ions estimation: Gravimetric, UV-Vis spectrophotometric, atomic absorption spectrometric, solvent extraction etc. Catalyst: General principles, homogeneous catalysts: hydrogenation of alkenes, hydroformylation, methanol carbonylation, Wacker oxidation of alkenes etc. Heterogeneous catalyst: hydrogenation catalysts, ammonia synthesis, alkene polymerisation (Zigler Natta catalyst). [11 hrs.] **Module - III** Physical Chemistry Thermodynamic condition of chemical equilibrium, Chemical potential, Activity, Fugacity, Gibbs-Duhem equation, Duhem-Margulesequatuion. 1st and 2nd order transition. Transition state theory towards rate of elementary chemical reaction, salt effect							

	on rate of a chemical reaction. photochemical and photophysical processes, Jablonsky diagram. Phase rule and its derivation, phase diagram of CO_2, H_2O and Sulphur system, two component system, solid-liquid and binary liquid mixture, fractional distillation, steam distillation, azotrope, ideal and nonideal solution, Routs law and Henrys law, Colligative properties. Conductance and tansport number, Buffer solution, Debye-Huckel limiting law, Salt effect and common ion effect on solubility of weak electrolytes. Ion-solvent and ion-ion interaction. Electrochemical cell with transference: liquid junction potential. [15 hrs.]
Text Books, and/or reference material	Suggested Text Books: (i) Organic Chemistry: R.T. Morrison and R.N Boyd, Prentice Hall of India Pvt.Ltd. (ii) Inorganic Chemistry Part-I & II, R. L. Dutta (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford (iv) Physical Chemistry by P. Atkins, Oxford (v) Physical Chemistry by G.W Castellan Suggested Reference Books: (i) Organic Chemistry by Volhardt (ii) Fundamentals of Analytical Chemistry By Skoog, West, Holler and Crouch (iii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	2	2	1	3	2	3
CO2	3	3	3	3	3	3	3	3	1	3	3	3
CO3	3	3	3	3	2	2	1	1	1	3	2	3
CO4	3	3	3	3	3	3	3	3	1	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS 381	**CHEMISTRY – II LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CYS 51		CT+ EA					
Course Outcomes	• CO1: To learn advanced chemical analysis useful for chemical engineering. • CO2: Estimation of metal ion concentration using advanced spectroscopic						

	techniques. • CO3: Advanced synthesis and characterization methods for few compounds of industrial importance.
Topics Covered	1. Determination of CMC of a surfactant: conductometrically and surface tension measurement. 2. Potentiometric titration: estimation of Fe^{2+} in Mohr's salt. 3. Determination of solubility product of lead iodide. 4. Kinetics of ester hydrolysis. 5. Spectroscopic Estimation of metal ion: Estimation of Cu^{2+}/ Cr^{3} 6. Estimation of metal ion: Estimation of Na^{+}, K^{+}, Ca^{2+} by Flame photometry 7. Estimation of base content of commercially available antacid and acid content of vitamin C. 8. Synthesis of Mohr's salt. 9. Synthesis of paracetamol. Analysis of pyrolusite ore.
Text Books, and/or reference material	Suggested Text Books: 1.Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Practical Chemistry by R.C. Bhattacharya Suggested Reference Books: 1. Selected experiments in Physical Chemistry by N. G. Mukherjee 2. Advanced Physical Chemistry Experiments: by Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V. K. Ahluwalia and S. Dhingra

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	3	2	3	3	2	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3
CO3	3	2	3	3	3	2	2	2	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHS 351	**CHEMICAL ENGINEERING COMPUTING LABORATORY-I**	PCR	0	0	3	3	1.5

<table>
<tr><td colspan="2">Pre-requisites</td><td></td></tr>
<tr><td colspan="2">Process calculations, Fluid mechanics, Thermodynamics</td><td>Viva-Voce</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">● CO1: To solve chemical Engg. problems using computers
● CO2: To use mathematical methods to solving chemical engineering problem</td></tr>
<tr><td>Topics Covered</td><td colspan="2">Module I
1. Familiarization of programming environment and execution of sample programs
2. Expression evaluation
3. Conditionals and branching
4. Iteration
5. Functions
6. Arrays [9 hrs.]
Module II
Solution of liner and non-liner algebraic equations
System of linear and non-liner algebraic equations [9 hrs.]
Module III
Initial value ODES using Euler explicit and implicit technique. Non-linear ODEs
System of Linear ODEs
System of non-liner and Stiff ODEs. [9 hrs.]
Module IV
The problems related to chemical engineering are given as laboratory assignments. Most of the problems deals with the various numerical methods taught in the Mathematics course. The problems on Phase Equilibrium, Equation of State, Determination of Bubble point and Dew Point calculation. [9 hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="2"><u>Suggested Text Books:</u>
1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.
2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
<u>Suggested Refernce Books:</u>
1. John H. Mathews, Numerical Methods Using FORTRAN. Prentice-Hall India
2. R. White and V. R. Subramanian, Computational Methods in Chemical Engineering.PHI.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2	2	2		2	2							2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHC401	**HEAT TRANSFER**	**PCR**	**3**	**1**	**0**	**4**	**4**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
CHC301, CHC303	CT+EA

Course Outcomes	• CO1:Illustrate principles and laws of heat transfer of different heat exchanging phenomena • CO2**:** Solve heat transfer problems of different difficulty levels • CO3**:**Design and analyze heat transfer equipment
Topics Covered	**Module - I** Mechanism of heat transmission: Conduction, Convection and Radiation. Conduction: Fourier's law; Steady-state heat transfer through plane wall and composite slabs, cylinders and spheres; Thermal contact resistance, Critical thickness of insulation, Optimum thickness of insulation; Unsteady-state heat transfer - use of Gurnie-Lurie chart, one and two-dimensional conduction in different geometry. [10 hrs.] **Module - II** Convection: Forced convection; Heat transfer coefficients; Overall Heat Transfer Coefficients; Log-mean temperature difference; Dimensional analysis of heat transfer; Equivalent diameter; General equation for forced convection; Thermal boundary layer; Analogy between heat and momentum transfer. [10 hrs.] **Module - III** Natural convection: Empirical equations; Condensation: Film Condensation, Derivation of heat transfer coefficient, Empirical equations; Boiling of liquids: Concept of excess temperature, Pool boiling, Forced convection boiling; Radiation: Black body and Gray body; Laws of radiation; View factor; Radiant heat exchange between surfaces [12hrs.] **Module - IV** Heat exchangers: Type of different heat exchangers and their design - Double pipe, Shell and tube, Finned tube and Compact heat exchangers; Condensers and reboilers. Evaporation: Type of evaporators with accessories; Capacity and Steam economy;

	Boiling point rise/elevation; Multiple effect evaporators; Design of single and multiple effect evaporators. [10 hrs.] Tutorial on above topics and class Tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Process Heat Transfer: D. Q. Kern, MGH 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. SuggestedReference Books: 1. Heat Transfer: An Engineering Approach: Cengel and Boles, Tata Mc-Graw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>CHC402</td><td>MECHANICAL OPERATIONS</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Fluid Mechanics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcome s</td><td colspan="7">● CO1: Identify principles of separation of liquid-solid, gas-solid, and solid-solid
● CO2: Design and analyze mechanical operation equipment
● CO3: Compare performances and select type of size separation, solid-liquid separation and size reduction equipment
● CO4: Learn industrial applications of size separation, solid-liquid separation, size reduction equipment</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module - I
Particle size and shape, particle size distribution: Determination of mean particle size, Sieve analysis, Industrial screens, Effectiveness of screens
Size reduction and classification of solid particles: Principles of crushing and grinding, Equipment – selection, Operating principles of Coarse crushing equipment, Intermediate & Grinding equipment, Laws of crushing and grinding – limitation and</td></tr>
</table>

	applicability Size enlargement: Granulation and other size enlargement operations. [18 hrs.] **Module - II** Agitation and mixing: solid-solid mixture, solid-liquid paste and solution preparation, Types of equipment and power requirement, Mixing Index.[8 hrs.] **Module - III** Fluid – particles separation: Terminal settling velocity, free and hindered settling, equal settling velocity and sedimentation; Classifications and clarifications; Settling chambers, thickening, tabling, jigging, floatation, centrifugal separators, centrifuge, cyclone separators, electro-static precipitator, magnetic separator, etc. [8 hrs.] **Module - IV** Filtration: Introduction; Types of filtration; Filtration equations; batch and continuous filtration equipment – Bed, Plate and Frame, Leaf and Rotary Drum Vacuum Filters; Filter Aid and Filter Medium; Washing Conveying of solids: Bins, silo and hoppers, Conveyors and elevators, Hydraulic and pneumatic transport [10 hrs.] Tutorial on above topics and class tests [14hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. G. G. Brown, Unit Operations, CBS Publishers & Distributors, 2005 2. W. McCabe. J. Smith, P .Harriott ,Unit Operations of Chemical Engineering ,McGraw Hill Education, 2017 Suggested Reference Books: 1. W.L. Badger and J. T. Banchero,Introduction to Chemical Engineering, McGraw-Hill book company, 1955 2. C.J.Geankoplis,Transport Processes and Separation Process Principles (Includes Unit Operations), Prentice Hall India Learning Private Limited, 2004 3. Richardson, Coulson and Richardson's Chemical Engineering, Volume 2, 5th Edition: Particle Technology And Separation Processes, Elsevier,2006

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3		3						3	
CO2	3		3		3						3	
CO3	3	3			3							
CO4	2	2	2		2			3	3	3	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engg							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC 403	**MASS TRANSFER- I**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1 Principles of mass transfer for chemical processes • CO2 Various laws of mass transfer and mass balance of chemical processes • CO3 Design and analyze mass transfer equipment through problem solution						
Topics Covered	**Module - I** Mass transfer operation and principles. General principles of diffusion process, Molecular and eddy diffusion in fluids, Diffusion in solids and measurement of diffusivity, Multi-component diffusion, Diffusion through a variable area, Knudsen diffusion, surface diffusion and self-diffusion [10 hrs.] **Module - II** Convective mass transfer and mass transfer coefficients: Introduction. Dimensionless groups in mass transfer and correlations for the convective mass transfer coefficient. Theories of mass transfer, Analogy between Momentum, Heat and Mass Transfer, Inter-phase mass transfer and Basic laws, Two-film theory, overall mass transfer coefficient, Material balance in contacting equipment – the operating line and Mass transfer in stage-wise contact of two phases. [10 hrs.] **Module III** Gas absorption and stripping: Introduction. Design of a packed tower: Design method based on individual mass transfer coefficients. Design method based on the overall mass transfer coefficient. Determination of the number of stages in a tray tower, HETP, Tray efficiency, Gas-liquid contacting equipment, tray or plate column, operational features of tray column: Hydraulic gradient and multi-pass trays, weeping and dumping, entrainment, flooding, turndown ratio and estimation of diameter of tray. [12 hrs] **Module IV** Elementary idea about multi-component absorption and adsorption with chemical reactions. Extraction: Liquid-liquid extraction, Equilibrium data, Use of triangular diagrams, selectivity and choice of solvent, Single and multi-stage calculation in liquid-liquid extraction. Extraction efficiency, Principles of leaching and stage calculation methods. [10 hrs.] Tutorial on above topics and class Tests [14 hrs]							
Text Books,	<u>Suggested Text Books:</u> 1. Mass Transfer Operations: R.E. Treybal						

and/or reference material	2. Principles of Mass Transfer & Separation Processes: B. K. Dutta Suggested Reference Books: 1. P. Sinha and P. De, Mass Transfer Principles and Operations, PHI 2. Chemical Engineering: 5th Ed., Coulson & Richardson

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	a	b	c	d	e	f	g	h	i	j	k	l
POs COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1		3			2				
CO2	3		3		3					1	3	1
CO3	3		3		3		1		1		3	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 432	**MECHANICAL DESIGN OF EQUIPMENT AND COMPONENTS**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To develop a workable idea of the thermo-mechanical behaviour of industrial equipment used in various chemical industries. • CO2: To study the application of different thermodynamic principles for thermal system design • CO3: To learn the concepts of stress and strain, the properties of engineering materials, and the methods of machine design pertaining to chemical engineering						

Topics Covered	**Module – I** Relation between system and control volume approaches, Equation of states. Zeroth, first and second law of thermodynamics. Gouy-Stodola theorem; Applications of SFEE. Carnot cycle, reversed Carnot cycle, Heat engine, heat pump and refrigerators. First and second law-based performances.Properties of pure substances, Vapour power cycle—Rankine cycle. Air standard cycles—Otto, Diesel, dual and Joule-Brayton cycles. [20 hrs.] **Module – II** Review of stress, strain and deformation. Engineering materials and their properties. General principle of machine design. Factor of safety,Use of data book in mechanical design. Design of shaft and key, Mechanical drives: Introduction to simple gear drive and belt drive. Types of pressure vessels: Thin cylinder and thick cylinder. [20 hrs.]
Text Books, and/or reference material	Suggested Text Books 1. Y. A. Cengel and M. A. Boles, Thermodynamics: An Engineering Approach, McGraw-Hill. 2. M. Zemansky and R. Dittman, Heat and Thermodynamics, McGraw-Hill. 3. V B Vhandari, Design of Machine elements [3rd edition] Suggested Reference Books: 1. M. Planck. Treatise on thermodynamics. Dover. 2. E. P. Gyftopoulos, G. P. Beretta, Thermodynamics: Foundations and applications, Dover.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1		1			1	1	3
CO2	3	3	3	1			1					3
CO3	3	3	3	1	1					2	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHS451	**FLUID MECHANICS LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
CHC 303 [Fluid Mechanics]		CE+EA					
Course Outcomes	• CO1To prove experimentally laws/equations like Bernoulli's equation, Fanning's equation, etc. • CO2. To determine discharge coefficients of flow meters like orifice and venture						

	meter, and velocity profiles using pitot tube ● CO3. To determine K factor of pipe fittings and valves ● CO4. To draw characteristic curves of pumps ● CO5. To create an experimental understanding of laminar and turbulent flow regimes
Topics Covered	1. To study different types of flow using Reynold's apparatus. 2. To verify Bernoulli's equation experimentally. 3. To determine point velocity by using Pitot tube. 4. To determine flow velocity by using Venturi meter and Orifice meter. 5. To study the flow characteristic in packed bed. 6. To study the flow characteristic in a helical coil. 7. To study the reciprocating pump characteristics. 8. To determine the losses due to friction in pipes and fittings. 9. Flow measurement by using V-notches [36 hrs]
Text Books, and/or reference material	Suggested Text Books 1. Transport Processes and Unit Operations - C. J. Geankoplis 2. Principle of Unit Operations – Foust A S, Wenzel L A, Curtis W, Maus L, Anderson L B (Wiley) Suggested Reference Books: 1. W. McCabe. J. Smith, P .Harriott ,*Unit Operations of Chemical Engineering*, McGraw Hill Education, 2017

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2	2	2		2	2							2
CO3	2	2		2	2							2
CO4	2	2		2	2							2
CO5	3	3		3	3							3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHS 452</td><td>PROCESS EQUIPMENT DESIGN-1</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">Report submission and Viva-Voce</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Knowledge of basics of process equipment design and important parameters of equipment design
● CO2: Ability to choose material for equipment design</td></tr>
</table>

	• CO3: Ability to design pressurize vessels and various parts of vessels • CO4: Knowledge of equipment fabrication and testing methods
Topics Covered	1. Introduction to the basic principles and criteria of pressure vessel design. 2. Unfired pressure vessels with internal and external and external pressure. 3. Introduction to standards, codes and regulations. 4. Selection of material and design of various parts of vessel 5. Design of storage vessels and their design. 6. Design of supports for vertical and horizontal towers. 7. Pipe joints and fittings, gaskets. 8. Sketching and drawing of vessel 9. Numerical solutions for vessel design [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Process Equipment Design by Lloyd E. Brownell & Edwin H. Young 2. Process Equipment Design by M. V. Joshi Suggested Reference Books: 1. Introduction to Chemical Equipment Design: Mechanical Aspects by B. C. Bhattacharya 2. Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus 3. Chemical Process Equipment: Selection and Design by James R. Couper

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	3	3	2	2	3
CO2	3	3	3	3	3	3	3	3	3	2	3	3
CO3	3	3	3	3	3	3	3	3	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Workshop							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Contact Hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
WSS481	**WORKSHOP PRACTICE-II**	PCR	**0**	**0**	**3**	**3**	**3**
Pre-requisites WSS51 (Workshop Practices)		Course Assessment methods : Viva-voce, Checking Job, Report					
Course Outcomes	• CO1: Acquiring the skills in conventional machining operations like turning, milling and knowledge in machine tools. • CO2: Acquiring the skills in CNC machining. • CO3: Acquiring the skills in Pattern making.						

	• CO4: Acquiring the skills in Foundry.
Topics Covered	Machine Shop : 1) Introduction to lathe Machine. 2) Explanation of All Gear Headstock Mechanism. 3) Explanation of Norton Gearbox Mechanism with Tumbler Gear Arrangement. 4) Job on Lathe & Milling Machine. CNC Shop : 1) Introduction to Conventional Machine, NC Machine & CNC Machine with their advantages & disadvantages. 2) Explanation of various G Codes & M Codes. 3) Introduction to programming on CNC Lathe & CNC Milling Machine. Pattern Shop : 1) Introduction to Pattern Shop 2) Drawing Orthographic Projection of a "V Block" Pattern using Pattern Maker Scale on a wooden board. 3) Preparation of a Wooden V Block Pattern using various carpentry tools in accordance with the previously prepared drawing. Foundry Shop : 1) Introduction to Metal Casting Process. ❖ General Foundry Safety Precautions. ❖ Process Selection of Casting. ❖ Classification of Pattern with Allowances. ❖ Tools & Equipment used in hand moulding. ❖ Organic & Inorganic Bonding agents used in moulding sand. ❖ Furnaces used for Melting. ❖ Casting Defects & their remedies. 2) Testing of Green Moulding Sand ❖ Preparation of Standard Sand Sample. ❖ Determining Moisture Content of Green Moulding Sand. ❖ To determine Green Compressive Strength of Sand Sample. ❖ To determine Green Shear Strength of Sand Sample. ❖ Determination of Permeability of Sand Sample. ❖ Mould Hardness Test. 3) Preparation of green sand mold using Split Pattern. 4) Preparation of green sand core using Split Core Box. 5) Casting of the above mould using Aluminium. 6) Foundry Tooling Design of Gate Valve Body with Selection of Parting Plane, Riser & Gating Design, Use of Chaplet, Chills & Ceramic Filters. [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Elements of Workshop Technology (Volume I and II) by Hazra and Choudhury 2. Workshop Technology by W.A.J. Chapman 3. A Course in Workshop Technology by Raghuwanshi Suggested Reference Books**:** 1. Principles of Foundry Technology by P.L. Jain 2. Production Technology, hmt

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs Cos	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	3	2	3	3	2	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3
CO3	3	2	3	3	3	2	2	2	3	3	2	3
CO4	3	2	3	3	3	2	2	2	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

<table>
<tr><th colspan="9">Department of Chemical Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHC501</td><td>CHEMICAL REACTION ENGINEERING</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="6">CT+MT + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the fundamentals of chemical kinetics
• CO2: Design and analyzeideal and non-ideal chemical reactors and bioreactors
• CO3: Design and analyze the fluid-solid catalytic &noncatalytic reactors, and fluid-fluid reactors</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module - I
Review of elements of reaction kinetics: The rate expression, mechanism of reactions, Arrhenius’ equation.
Interpretation of rate data: Constant volume and variable volume batch reactors [6 hrs.]

Module - II
Single homogeneous reaction: Design of isothermal and adiabatic batch, plug flow and back mix reactors
Multiple reactions: Independent, parallel and series reactions, autocatalytic reactions. Choice of reactors for single and multiple reactions and multiple reactor systems [12 hrs.]

Module - III
Biochemical reactions: Enzyme-catalyzed and biomass growth reaction kinetics, design of bioreactors
Non-ideal flow in reactors:, residence time distribution of fluid in vessels, RTD in ideal and non-ideal reactors, modeling of non-ideal reactors [8 hrs.]

Module - IV
Solid-fluid catalyzed reactions: Catalysis, porous catalyst, steps in catalytic reactions, surface kinetics, pore diffusion resistance, performance equations, interaction of physical and chemical rate processes, effectiveness factor, selectivity, product distribution in multiple reactions, effect of pore distribution, experimental methods. Catalytic reactors
Fluid-fluid reactions: Overall rate equations, application to reactor design [9hrs.]

Module - IV
Solid-fluid noncatalytic reactions: Shrinking core model, determination of rate-</td></tr>
</table>

	controlling steps and application to design of reactors [7hrs.] Tutorial on above topics and class tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India 2. O. Levenspiel, Chemical Reaction Engineering, Wiley. Suggested Reference Books: 1. J M Smith Chemical Engineering Kinetics, McGraw-Hill Education; 3rd edition

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
CHC 502	**MASS TRANSFER-II**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHC 403, CHC301		CT+MT+EA					
Course Outcomes	• CO1: Understanding fundamentals of some major Mass transfer operations • CO2: Application of design principles for mass transfer devices • CO3: Learning operations of various mass transfer systems • CO4: Building foundation for process intensification • CO5:Motivation towards innovations for novel systems of mass transfer						
Topics Covered	**Module-I** Humidification & Dehumidification Operations: Principles of Humidification & Dehumidification Wet & dry bulb thermometry, Construction and use of humidity charts, characteristics of saturated and unsaturated vapor- gas mixtures, design & operation of cooling tower, Design problems [10 hrs.] **Module-II** Drying: Theory and mechanism of drying, steady and unsteady state drying, classification and selection of industrial dryers, estimation of drying rates, drying characteristics of materials, performance and design of batch and continuous dryers						

	[10 hrs.] **Module-III** Distillation processes: Vapor- liquid equilibrium, relative volatility, azeotropism, Equilibrium and flash distillation, types of distillation columns and construction, Rectification of binary systems, enthalpy-composition diagram and construction. [6 hrs.] **Module-IV** Rectification column design methods: Lewis-Sorel &Ponchon–Savarit, McCabe-Thiele method, Design problems [6 hrs.] **Module-V** Special distillation processes: Membrane, molecular, extractive, catalytic Distillation, multi-component Distillation & introduction to ASPEN PLUS [9 hrs.] **Module-VI** Theory of crystallization, Nucleation and crystal growth, Batch and continuous crystallizers, Design calculations for crystallizers [3 hrs.] **Module- VII** Membrane separation basics, classification, transport & exclusion mechanisms, Membrane modules and design problems on micro, ultra, nano& reverse osmosis [3hrs.] Tutorial on above topics and class Tests [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Unit Operations of Chemical Engineering: W.L. McCabe & J.C. Smith 2. Principles of Mass Transfer & Separation Processes: B. K. Dutta 3. Mass Transfer Operations: R.E. Treybal Suggested Reference Books: 1. Introduction to chemical engineering: W.L.Badger&J.T.Banchero 2. Membrane Science & Technology, Osada& Nakagawa 3. Industrial Water Treatment Process Technology, P. Pal, Elsevier Science 4. Chemical Engineering: Coulson & Richardson 5. Principles of Unit Operation: C. J. Geankoplis

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	2	2	2	1	2	2	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	2	1	2	2	1	3	2
CO4	3	2	3	1	2	1	1	3	2	2	3	2
CO5	3	1	2	2	2	3	1	2	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>CHC503</td><td>CHEMICAL PROCESS TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Knowledge of Unit operations and Unit processes</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1:Ability to understand the manufacturing of various inorganic and organic chemicals.
● CO2: Ability to understand the process flow diagram and various process parameters.
● CO3: Ability to identify and solve engineering problems during production.
● CO4: Knows current scenario of chemical & allied process industries.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Basic philosophy of a process flow diagram (PFD). Elements of a PFD. General discussion on Influence of various parameters on deciding process for a product and method of drawing PFD.
Water-sources and it’s economic use. Water conditioning processes, Industrial waste water treatment - different processes
Industrial production of oxygen and nitrogen, cryogenic and non-cryogenic processes. Hydrogen manufacture from different source-steam reforming and partial oxidation processes.
Cement, glass, ceramic industries: Raw materials, principles of manufacture, flow-sheet [20 hrs.]

Module II:
Chlor-alkali industries: Production and consumption pattern, manufacture of Chlorine-caustic soda: Raw materials, principles of manufacture, Mercury-cathode & Membrane process: flow-sheet and sequence of operation, other processes, advancement of process technology and major engineering problems, uses.
Soda-ash: Production and consumption pattern, Raw materials, Solvey process Physico-chemical principles of manufacture, carbonation and ammonia recovery step, flow-sheet and sequence of operation, other processes, advancement of process technology and modified Solvey process, major engineering problems, uses. [12 hrs.]

Module III:
Industrial Acids:
Hydrochloric Acid: Raw materials, principles of manufacture, flow-sheet and</td></tr>
</table>

	sequence of operation, Sulfuric acid: sulfuric acid production process, Contact process, Physico-chemical principles and general theory of contact reaction with thermodynamic and reaction engineering aspects, different types of catalyst, DCDA process, uses. Nitric Acid: Raw materials, Ostwald Process –physico-chemical principles, catalyst, process flow sheet, Phosphoric Acid: Raw materials, manufacturing process with process flow sheet [5 hrs.] **Module IV:** Fertilizer Industries: Nitrogenous fertilizers: Synthesis of ammonia- physico chemical principles, catalyst for synthesis of ammonia, process flow sheet, Urea - Raw materials, manufacturing process with flow sheet, sequence of operation, Ammonium sulphate: Raw materials, manufacturing process with flow sheet, Phosphatic fertilizers: Manufacturing process of super phosphate of lime ,triple super phosphate and ammonium phosphate, Mixed fertilizers: NPK –manufacturing process, details of major equipment.[7 hrs.] **Module V:** Organic chemical industries Oils & Fats: Methods of extracting vegetable oils, Hydrogenation of oils, major engineering problems and improved technology Soaps, Detergents &Glycerin: Classification of cleaning compounds, uses, Methods of soap production, Methods of detergent manufacture, Methods of production of Glycerin. Process description& flow sheet of each process. Sugar and starch industries: Manufacturing process with flow diagram, Sugar refining, manufacturing process of starch and their different by-products; Glucose, Sorbitol & PolyolsPulp and paper Industries, technology and manufacturing methods, world market [12hrs.]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press. 2. Austins, G.T., Sherve's Chemical Process Industries, MGH 5thEdn. <u>Suggested Reference Books:</u> 1. Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, IIT, Madras. 2. S. K. Ghoshal, S. K. Sanyal and S. Datta, Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi. 3. Kirk &Othmer (Ed.), Encyclopedia of Chemical Technology

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2	3		3							
CO2		2										
CO3					3							

CO4										1	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>CHC504</td><td>PROCESS CONTROL AND INSTRUMENTATION</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Knowledge of applied mathematics, Unit operations</td><td colspan="5">CE+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understanding the working principle of various measuring instruments like, level, temperature, pressure, flow and concentration etc.
CO2: Process modeling fundamentals: Differential equation models, Laplace transforms, linearization, idealized dynamic behavior, transfer functions, block diagram, and process optimization.
CO3: Evaluate stability, frequency response, and other characteristics relevant to process control.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Introduction to Instrumentation
Measurement of High temperature, Measurement of Moderate to Low Temperature, Measurement of High Pressure, Measurement of Moderate to Low Pressure, Measurement of gas and liquid flow, Measurement of multiphase flow, Measurement of liquid level & Composition [15hrs.]

Module II:
Process Dynamics & Transfer function
Process Dynamics & Model: I/O model-first-order and second-order process, Linearization and concept of deviation variable, Laplace Transform, Block Diagram, Different forcing function: step, pulse, impulse, ramp, and sinusoid. Lumped and distributed parameter system
Transfer function: SISO & MIMO systems, Transient response of first, second and higher order systems, Transportation lag; Pade approximation, Control valve: Characteristics curves and transfer function. Open loop transfer [10 hrs.]

Module III:
Closed loop systems and Stability
Closed loop systems and its components: Measuring device, Controller, Final Control</td></tr>
</table>

	Element (FCE), transmission line; Block diagram, Servo and Regulator control, closed loop response, Different type of analog controller: P, PI, PD, PID, On-Off. Concept of Stability: BIBO, characteristics equation, Routh– Hurwitz method, root locus method. Frequency Response Analysis and Controller Tuning: Amplitude Ratio and Phase Lag calculation for: General, first, second and higher order systems, Dead time, P, PI, PD, PID controllers and their respective Bode plot &Nyquist plot; Bode &Nyquist stability criteria; [10 hrs.] **Module IV:** Controller design Empirical tuning criteria: one quarter decay ratio, ISE, IAE, ITAE. Controller tuning: Cohen-Coon, Zeigler-Nicholas method; Elementary idea of feed forward, cascade, ratio, adaptive and digital computer control. Model-based control –Internal model controller [7hrs.]
Text Books, and/or reference material	<u>SuggestedText Book:</u> 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. Chemical Process control, G. Stephanopoulos, PHI, 2008 3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996) <u>Suggested Reference Books:</u> 1. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1						1	
CO2	3	2	1								1	
CO3	3	2	1		1						1	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 551	**HEAT TRANSFER LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods: Continuous (CT) and Viva-Voce					

Basic knowledge of heat transfer	CT+Viva-Voce
Course Outcomes	● CO1: Apply the knowledge of fundamentals of heat transfer equipment on laboratory ● CO2: Experimentation and data analysis ● CO3: Handling various instruments and solve various difficulty levels ● CO4: Learn industrial applications of heat transfer equipment ● CO5: Complete process design through assignment / group task
Topics Covered	1. Determination of overall heat transfer coefficient using plate type heat exchanger 2. Determination of overall heat transfer coefficient for drop wise & film wise condensation 3. Determination of overall heat transfer coefficient using counter flow/parallel flow concentric pipe heat exchanger. 4. Determination of boiling point elevation of aqueous salt solutions. 5. Determination of thermal conductivity of metal rod. 6. Determination of emissivity for black body and test plate. 7. Determination of overall heat transfer coefficient using shell and tube heat exchanger. [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Laboratory manual Suggested Reference Books: 1. Process Heat Transfer: D Q Kern 2. Heat Transfer: Principles and Applications: B. K Dutta

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2		3	2									
CO3			3		2							
CO4			3		2							
CO5											2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS552	**MECHANICAL OPERATION LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites							
	Viva-Voce						

Course Outcomes	• CO1: Understand of the fundamental principles underlying mechanical operation through practical experimentation. • CO2: Know the principles of different mechanical operation equipment. • CO3: Design and analyse mechanical operation equipment. • CO4: Compare performances and select type of mechanical operation equipment. • CO4: Learn industrial applications of size reduction equipment (k)
Topics Covered	1. To verify Rittinger's Law in a Jaw Crusher 2. To Study comminution through a Ball Mill and calculate its theoretical Efficiency 3. Studies on the performance of the Cyclone Separator-(I. To study the characteristics of a cyclone separator. II. To measure the fractional collection efficiency of different particle size ratio) 4. To determine overall effectiveness of a vibrating screen for a given solid sample of unknown size 5. To determine the mixing index of flour and pulses in kneader mixer 6. To determine the power consumption in a propeller mixer and compare it with the actual power requirements in agitated vessel 7. To run the operation of Plate and Frame Filter Press For filtration of calcium carbonate slurry. (I. To determine the lost quantity of calcium carbonate after filtration process.) 8. To study the influence of different flow rates of water on separation efficiency of an Elutriator 9. To determine average size of a group of particles in a mixture based on volume and surface and graphical representation of screen analysis data for size distribution of the mixture. 10. To study the working of continuous type thickener [36 hrs]
Text Books, and/or reference material	Suggested Text Books: Lab Manual 1. Unit Operations- G. G Brown (CBS Publishers & Distribution) 2. Introduction to Chemical Engineering-Badger and Banchero (McGraw-Hill) 3. Transport Processes and Unit Operation-C. J. Geankoplis (Prentice-Hall India) Suggested Reference Books: 1. Mechanical Operations for Chemical Engineers-C.M. Narayanan, B.C. Bhattacharyya (Khanna Publishers) 2. Unit Operations Of Chemical Engineering-Mc. Cabe Smith &Harriot (TMH) 3. Unit Operation-C.J. King 4. Coulson & Richardson's Chemical Engineering Volume.2

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2		3	2									
CO3			3		2							
CO4			3		2							
CO5											2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="10">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHS553</td><td>PROCESS EQUIPMENT DESIGNS 2</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5"></td></tr>
<tr><td colspan="3">Heat Transfer, Process Equipment Design 1</td><td colspan="5">Viva-Voce</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Ability to design Evaporator and techno-economic evaluation
CO2: Ability to design Shell and Tube Heat Exchanger and selection of materials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Design of Multiple Effects Evaporator and techno-economic evaluation.
2. Selection of material Design of Shell and tube heat exchanger [36 hrs]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Process Heat Transfer by Kern
2. Coulson & Richardson’s Chemical Engineering Design (Vol 6)
3. Process Equipment Design by Lloyd E. Brownell & Edwin H. Young
4. Process Equipment Design by M. V. Joshi

<u>Suggested Reference Books:</u>
1. Introduction to Chemical Equipment Design: Mechanical Aspects by B. C. Bhattacharya
2. Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus
3. C
hemical Process Equipment: Selection and Design by James R. Couper.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1		1							

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	**ECONOMICS AND MANAGEMENT ACCOUNTANCY**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	● CO1: To review basic economic principles with students; ● CO2: To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works; ● CO3: To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.						
Topics Covered	**Module I:** PART 1: Economics Group A: Microeconomics Economics: Basic Concepts Theory of Production, Cost and Firms, Analyses of Market Structures: Perfect Competition, Monopoly Market, General Equilibrium & Welfare Economics [14 hrs.] **Module II:** Group B: Macroeconomics Introduction to Macroeconomic Theory, National Income Accounting, Determination of Equilibrium Level of Income, Money, Interest and Income, Inflationand Unemployment, Output, Price and Employment. [14 hrs.] **Module III:** PART 2: Accountancy Introduction to Accounting, Financial Statement Preparation and Analysis. Financial Ratio Analysis. [14 hrs.]							
Text Books, and/or reference material	<u>Suggested Text Books</u> 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 4. Ashoke Banerjee: Financial Accounting; Excel Books 5. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed)							

	6. N. G. Mankiw: Macroeconomics, Worth Publishers Suggested Reference book 1. Dornbush and Fisher: Macroeconomic Theory 2. SoumyenSikder: Principles of Macroeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics 5. Maheshwari: Introduction to Accounting; Vikas Publishing 6. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC601	**TRANSPORT PHENOMENA**	PCR	3	1	0	4	4
Pre-requisites CHC301, CHC303,CHC401, CHC403,CHC501, CHC502		Course Assessment methods(Continuous (CT)and end assessment(EA))					
		CT+EA					
Course Outcomes (CO)	• CO1:To create an understanding on universal approach of transport Phenomena and fundamental transport processes like mass, momentum and energy. • CO2:Togivean understanding onshellbalancetechnique, settingof boundaryconditions etc.fordifferent geometryofasystem • CO3:TodevelopNSE, equation ofcontinuity, equationofenergyetc. from thefundamental conceptofconservation • CO4:To solveproblemsonmass,momentumandenergytransportusing shellbalancetechniques andbasictransportequations						

Topics Covered	**Module I** Transport Phenomena: Basic concepts, fundamental transport Processes and theirrelation, transport properties, measurement of properties, boundary conditionsetc. [6hrs.] **Module II:** Momentumtransport phenomena: Shell balance technique, Derivationmomentum,velocity, shear force. in rectangular, cylindrical and spherical coordinate systems by using shell balance, Equation of continuity and change (mass, momentum & energy), Navier stokes equation (NSE), Euler equation, application of NSE in rectangular, cylindrical and spherical coordinate systems. [10 hrs.] **Module III :** Flow of fluids in thin films, parallel plates, circular tubes and annulus, adjacent flow of two immiscible fluids, couetteflow, rotating surface flow and radial flow, flow near a wall suddenly set in motion.[10 hrs.] **Module IV:** Energy transport: Basic energy transport equations, derivation using elementary volume concept and conservation theorems in different coordinate system, analysis of energy transport using hell balance techniques and basic transport equations. [8 hrs.] **Module V:** Conduction with energy sources in fixed bed catalytic reactors and in cooling fins, forced convection circular tubes, natural convection from a heated plate and unsteady state conduction of inthe slab [10 hrs.] **Module VI:** Mass transport: Types of fluxes and their relation, continuity equation for a binary mixture, boundary conditions , analysis of mass transport using shell balancetechniques andequation of continuity fordifferent coordinate systems, steadyand unsteadystate systems, diffusion in porous catalyst with and without chemical reaction, diffusion in falling liquid film, turbulent mass flux, interphasemass transport [12hrs.]
TextBooks, and/or reference material	<u>Suggested TextBooks:</u> 1. TransportPhenomena byBird,Stewart&Lightfoot, Wiley, 2nd Edition,2010. 2. Introduction toTransportPhenomena:Momentum, HeatandMassby BodhRaj,PHILearning, 2012 <u>Suggested ReferenceBooks:</u> 1.TransportPhenomena:AUnified Approachby Brodkey&Hershey,McGraw-HillChemicalEngineering Series,BrodkeyPublishing, 2003

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2		2	2	2	2							3
CO3			2	2	3						3	3
CO4		3	3	3	3						3	3

Correlation levels1,2or3asdefinedbelow:
1:Slight(Low) 2:Moderate(Medium) 3:Substantial(High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC602	**PETROLEUM REFINING & PETROCHEMICALS**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Understanding technical, economic, environmental and international market issues in petroleum refining business • CO2: Understanding correlation of petroleum properties with system design and operation • CO3: Understanding design and safe operation of complex refinery units for various petroleum products • CO4: Knowledge of application of Chemical Engineering Principles in one of most relevant industrial sectors of the economy • CO5: Ignited minds with passion for innovation and sustainable development						
Topics Covered	**Module I:** Petroleum - Origin and Occurrence, Exploration, Estimation and recovery [3 hrs.] **Module II:** Evaluation of crude, Properties, testing and specifications of petroleum products [6hrs.] **Module III:** Technical, Economic, environmental and societal issuesinPetroleum Refining and marketing business. [4 hrs.] **Module IV:** Processing of Crude Petroleum: crude pre-treatment, Atmospheric and Vacuum distillation, column control schemes. [6 hrs.] **Module V:** Cracking, Reforming, Vis-breaking, Delayed Coking processes to cater to the market demand of various petroproducts, Environmental pollution associated with such processing and abatement strategies [10 hrs.] **Module VI**: Rebuilding possibilities with small molecules**:** Alkylation, Isomerization. [3 hrs.]						

	Module VII: Production of finished petroleum goods like, LPG, Kerosene, Petrol, Diesel, Lubricating Oil, Bitumen, Hydro processing; Innovations and novel approaches in Hydrogen production as green fuel. [10 hrs.] **Module VIII:** Petrochemical- feedstocks, classification of petrochemicals, Cracking of raw feed stock for intermediate feed stock production, manufacture of importantpetrochemicalproducts [8 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Petroleum Refining Engineering: W.L. Nelson 2. Advanced Petroleum Refining: G.M. Sarkar 3. Modern Petroleum Refining: B.K.B. Rao 4. Petroleum Refining: J.P. Fauquier 5. Petroleum Refining Technology: Ram Das Suggested Reference Books: 1. Catalytic Naphtha Reforming: Sc. & Technology: G.M. Antos, A.M. Aitani, J.M. Pereira 2. Environmental Control in Petroleum Refining: J.C. Reis 3. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk 4. Petrochemicals Technology: B.K.B. Rao 5. Lubricant base oil and wax processing: AvilinoSequeira Jr. 6. Hydrocarbon Technology Journal (Center for High Technology, Delhi)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	2	2	2	3	1	3	1	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	3	1	2	2	1	3	2
CO4	3	2	2	3	1	1	1	3	2	3	3	2
CO5	3	1	2	3	2	3	1	2	3	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC 603	**PROCESS MODELLING AND SIMULATION**	PEL	3	0	0	3	3
Pre-requisites: Process calculation, Engg. Math I-III			Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))				
			CT+MT+EA				

Course Outcome	• CO1: Understanding the principle ofmass, energy and momentum conservation equations. • CO2: Concept of steady state and unsteady state model equations • CO3: Numerical techniques to solve Algebraic, ODE and PDE • CO4: Solution of various model equationsand graphical presentation
Topics Covered	**Module I:** Introduction to Mathematical Model and its Necessity: Empirical relationship, experimentation, data interpretation, correlation and mathematical modelling using example Model Development Principles and Classification of Models: Dimensional Analysis, Synthesis of sub-models, Experimental facts, Hypothesis, Scale up concept, Steady state, unsteady state model, dynamic response, Constitutive relationships, Deterministic and Stochastic – Macroscopic diffusion equation, Lumped and Distributed Parameter - Stirred tank and plug flow models, Linear and non-linear models Conservation principles of mass and energy and momentum balance equations and Modelling of few simple systems**,** Gravity flow tank, Flash drum, Distillation column, Double pipe heat exchanger, Gas-liquid absorption column, CSTR, Batch reactor, Plug flow reactor. **[**18 hrs.] **Module II:** Development of dynamic model, Input output model vs. state model, system parameters, numerical integration,Linear models and deviation variables, linearization of non-linear models, System with one state variables, one input. State space model,Heated mixing tank, Isothermal CSTR, Non-isothermal CSTR with 2nd order chemical reaction, linearized model for the system and state space representation, Stability analysis and Eigen values. Model development ofPyrolysis, Combustion, Gasification process of coal and biomass and comprehensive modellingin TGDA, Isothermal mass loss Apparatus. [12 hrs.] **Module III:** Specialized Modeling for distributed parameter system: Distributed parameter system and model equations,the general conservation equation and interpretation of individual terms, Detail derivation of Finite Volume Method (FVM) and its application to steady state diffusive, convective and convective-diffusive problem. Extensions of the same for unsteady state operation, Presence of non-linear reaction terms, radiation term and linearization technique. Solution ofmodel equations. [14hrs.] Tutorial and class test [14 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1.*Lyuben*, W.L, *Process Modelling*, Simulation and Control, McGraw-Hill, N.Y. 1990. Suggested Reference books: 1. Patankar, S. V., 'Numerical fluid flow and heat transfer', 1980, Hemisphere

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	1	1	2	1	2	2	1
CO2	3	3	3	2	3	2	1	3	1	3	3	1
CO3	3	3	3	2	3	2	1	3	1	3	3	1
CO4	3	3	3	2	3	2	1	3	1	3	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 651	**FUEL LABORATORY**	PCR	0	0	3	3	1.5
Pre-requisites							
		Viva-Voce					
Course Outcomes	● CO1: Demonstrate and understand the principles of fuel properties testing instrument. ● CO2:Conduct the experiments for determination of properties of different fuels. ● CO3:Analyze the performance of equipment through group tasks.						
Topics Covered	1. Proximate Analysis of Coal determines the moisture ash, volatile matter and fixed carbon of coal in terms of weight percentage. 2. Shattering Index of Coke 3. Caking Index 4. Swelling Index 5. Viscosity of Fuel Oils 6. Determination of Flash point and Fire point of an oil by closed cup Pensky Martin Apparatus 7. Determination of moisture content of fuel oil by Dean and Stark Apparatus 8. Aniline point determination by thin film 9. Determination of vapour pressure of petroleum products using Reid Apparatus. 10. To perform atmospheric distillation of petroleum product and to find out percent recovery, percent total recovery, percent loss, percent residue. 11. Determination of calorific value of solid fuel by Bomb Calorimeter 12. Determination of carbon residue of fuel by Conradson Method [36 hrs.]						
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Modern Petroleum Refining: B. K. B. Rao 2. Fuels & Combustion: Samir Sarkar <u>Suggested Reference Books:</u> 1. Petroleum Refining Engineering: W. L. Nelson 2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1							1
CO2	2	2		2	2							2
CO3	2	2		2	2							2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHS652</td><td>REACTION ENGINEERING LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="6">Viva-Voce</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
• CO1:Understand the fundamental principles of reaction kinetics in different reactor through practical experimentation
• CO2:Study the non-catalytic homogeneous saponification reaction in CSTR and residence time distribution in a CSTR.
• CO3:Study the non-catalytic homogeneous saponification reaction in plug flow reactor.
• CO4:Study the non-catalytic homogeneous saponification reaction in isothermal batch reactor.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
1. Study of Non-catalytic homogeneous reaction in an Isothermal Batch Reactor.
2. Study of non-catalytic homogeneous saponification reaction in a tubular flow reactor and to interpret the kinetic data of the given reaction in the form of a rate equation.
3. Residence distribution (RTD) Studies in CSTR.
4. Study of non-catalytic homogeneous saponification reaction in a continuous stirred tank reactor and to interpret the kinetic data of the given reaction in the form of a rate equation.
5. Removal of dye using Fenton oxidation process and evaluation of its Kinetic data.
6. Study the performance of a cascade of three equal volume CSTRs in series for the saponification of ethyl acetate with NaOH.
7. Study RTD of a packed bed reactor. [36 hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">
<u>Suggested Text Books:</u>
1. Laboratory Manual
2. Chemical Reaction Engineering, Octave Levenspiel , Wiley; Third edition (2006)
3. Elements of Chemical Reaction Engineering 4th Ed - H. Scott Fogler
<u>Suggested Reference Books:</u>
1. The engineering of chemical reactions, Lanny D. Schmidt, Oxford University Press Inc; 2nd edition (2004)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	2	2	2	1	2	2	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	2	1	2	2	1	3	2
CO4	3	2	3	1	2	1	1	3	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHS653</td><td colspan="2">MASS TRANSFER LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6"></td></tr>
<tr><td colspan="3"></td><td colspan="6">Viva-Voce</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">● CO1: To demonstrate an understanding of mass transfer modes and models
● CO2: To formulate the idea of the different types of set up
● CO3:To apply principles of mass transfer phenomena to chemical process industries
● CO4: To enable solving the problems on process and materials related to mass transfer phenomena</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">1. Study the characteristics of simple batch distillation
2. Determination of diffusivity of a hydrocarbon liquid through air
3. Study the performance of drying in atmospheric tray drier
4. Find out the heat transfer co-efficient for drop wise & film wise condensation
5. Study characteristics of bubble cap column
6. Determination of overall heat transfer coefficient of an open pan evaporator
7. Calculate hold up in a rotary drier
8. Experiment on flooding & loading phenomena in a packed absorption tower
[36 hrs.]</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Mass Transfer: R.E.Treybal
2. Unit operations of chemical engineering: W.L. McCabe &J.C.Smith
3. Laboratory manual

<u>Suggested Reference Books:</u>
1. Principles of Mass Transfer & Separation Processes: B. K. Dutta</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	3	2	2	2	1	2	2	1
CO2	3	2	3	2	3	1	1	2	1	2	2	2
CO3	3	1	3	2	2	2	1	2	2	1	3	2
CO4	3	2	3	1	2	1	1	3	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Sixth Semester Departmental Depth Elective Subjects

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE610	**CHEMICAL REACTOR ANALYSIS**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term and end assessment (EA))					
CHC501		CT+MT+EA					
Course Outcomes	• CO1: Design & analyze fluid-solidnon-catalytic, catalytic and fluid-fluid reactors • CO2: Design &analyse multiphase reactors • CO3: Design and analyze bioreactors and non-ideal reactors • CO4: Analyse the thermal instability of CSTRs						
Topics Covered	**Module I:** Design and analysis of non-catalytic solid-fluid reactors [3 hrs.] **Module II:** Analysis of catalytic reactors: Packed, Moving-bed and Fluidized-bed reactors [10hrs.] **Module III:** Multiphase reactors: slurry and trickle bed reactors [9hrs.] **Module IV:** Multiple steady states and thermal instability of reactors; Dynamic analysis of CSTR; Sustained oscillation and limit cycle [5hrs.] **Module V:** Modelling of non-ideal reactors [4hrs.] **Module VI:** Biochemical reactor design [2hrs.]						

	Module VII: Fluid-fluid reactor design [5 hrs.] Tutorial on above topics and class tests [4hrs.]
Text Books, and/or reference material	Suggested Text books: 1. H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India. 2. O. Levenspiel, Chemical Reaction Engineering, Wiley. Suggested Reference book: 1. Chemical Reactor Analysis and Design - G F Froment& K B Bischoff (Wiley).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE611	**INDUSTRIAL POLLUTION CONTROL AND TREATMENT**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Knowledge of all Unit Operations and Unit processes		CT+MT+EA					
Course Outcomes	• CO1: The fundamental concepts in environmental engineering dealing with water, air, and land pollution. • CO2: Graduates will learn a solid foundation in mathematics, sciences, and technical skills needed to analyze and design environmental engineering systems. • CO3: Graduates will be familiar with current and emerging environmental engineering and global issues, and have an understanding of ethical and societal responsibilities. • CO4: The necessary qualifications for employment in environmental engineering						

	and related professions, for entry into advanced studies, and for assuming eventual leadership roles in their profession.
Topics Covered	**Module I:** Introduction to Water Treatment: National & International Scenario; World-wide Water resources Management; Water quality standards – Drinking water standards; Industrial effluent standards [3 hrs] **Module II:** Physico-Chemical Treatment Technology: Aeration, Ion exchange, Ozone treatment, adsorption. Chemical coagulation-precipitation, settling, flocculation theorems, Chlorination, advanced scheme for municipal water treatment.[6hrs.] **Module III:** Biological Treatment: Basics of biological water treatment, relevant kinetics, biological reactor configurations, Activated sludge process, trickling filtration, lagoon treatment, submerged aerators, upward flow sludge blanket reactor, rotating disc biological contactors, advances in biological treatment. [7hrs.] **Module IV:** Membrane Treatment: Different membranes and modules in water treatment; Transport mechanisms in membrane separation; Principles of Forward and Reverse osmosis; Membrane distillation, Micro and ultrafiltration; Nanofiltration and hybrid processes in water treatment processes.[7 hrs.] **Module V:** Industry-specific advanced water treatment schemes: Petroleum refinery waste treatment, coke-oven waste treatment, pharmaceutical waste treatment, tannery wastewater treatment.[5 hrs.] **Module VI** Air Pollution Environmental threats Role of Atmosphere in dispersion , Plume behavior Dispersion problems and Stack Design(Tutorial): Control devices –Cyclone Separators, ESP, Venturi scrubber, gravity separator, filters Design Problems (Tutorial) Abatement of gaseous pollutants & VOCs [10 hrs.] **ModuleVII:** Solid and hazardous Waste management [4 hrs.]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Industrial water treatment Process Technology, P. Pal, Elsevier Science 2. Membrane Technology in Environmental Pollution Control, P.Pal 3. Environmental Pollution Control Engineering – C.S. Rao <u>Suggested Reference Books</u>: 1. Groundwater Arsenic remediation: Treatment Technology and Scale up, P. Pal, Elsevier Science

	2. Handbook of Chlorination and Alternative disinfection, Geo. Clifford White, Wiley 3. Water Treatment Plant Design, Stephen J. Randtke, Michael B. Horsley(EDs.), ASCE 4.Water Technology, N.F. Gray, Elsevier Science

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							3					
CO2	3	3	3			1						
CO3								3				
CO4						1			1		1	

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE612	**NON-CONVENTIONAL ENERGY ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CHC401		CT+EA					
Course Outcomes	● CO1: Learn about energy technology of different conventional and non-conventional energy resource and Recent worldwide energy market scenario ● CO2: Design & analyze of different renewable energy collectors and renewable energy thermal power plants ● CO3: Learn industrial and domestic applications of different renewable energy sources ● CO4: Solve energy technology problems of different difficulty levels through tutorials						
Topics Covered	**Module I:** Wind Energy: Sources and potentials, Wind energy conversion, General formula -Lift and Drag- Basis of wind energy conversion – Effect of density, frequency variances, angle of attack, and wind speed. Windmill rotors Horizontal axis and vertical axis rotors. Determination of torque coefficient, horizontal and vertical axis windmills, performance characteristics, Betz criteria, Design and analysis of wind turbines.						

	geographical aspects. [10 hrs.] **Module II:** Solar Energy: Energy available form Sun, Solar radiation data, Solar energy conversion into heat, Flat plate and Concentrating collectors, Construction and performance analysis of solar flat plate collectors, Mathematical analysis of Flat plate collectors and collector efficiency, collector efficiency factor, tilt factors, collector heat removal factor, Hottel-Willier-Bliss equation. Principle of Natural and Forced convection, Salt gradient solar ponds: construction, operation, technical problems, Solar drying and dehumidification: Solar cabinet dryers, convective dryers Solar engines-Stirling, Brayton engines, Photovoltaic, p-n junction, solar cells, PV systems, Stand-alone, Grid connected solar power satellite. [10 hrs.] **Module III:** Nuclear Energy: Nuclear fission principles, types of nuclear reactors (BWR, PWR, PHWR, LMCR, GCR, FFR). Nuclear reactor analysis: four factor formula, resonance absorption, reactor buckling, multiplication factor, thermal utilisation coefficient, reflector saving, fast fission factor, optimum moderator to fuel ratio. Radioactive waste disposal Energy from Ocean: Wave, Tidal and OTEC energy- Difference between tidal and wave power generation, Principles of tidal and wave power generation, OTEC power plants (closed cycle, open cycle, hybrid cycle), operation and technical problems, environmental impact, Tidal power, salinity power plants, Geothermal systems: Resources, types of wells, methods of harnessing the energy, Hot water and dry steam systems, energy extraction principles. [10 hrs.] **Module IV:** Energy from biomass: Biomass utilization: pyrolysis, gasification, anaerobic digestion (biogas production). Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, Biodiesels: Manufacture and characteristics. Gasohol: Characteristics and manufacture, use of pervaporation technology. Synthetic liquid fuels from coal: F – T Process, Coal hydrogenation, MTOG process. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1.Ashok V Desai, Non-Conventional Energy, Wiley Eastern Ltd, New Delhi, 2003 2.K M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, New Delhi, 2003. Suggested Reference Books: 1. Ramesh R & Kumar K U, Renewable Energy Technologies, Narosa Publishing House, New Delhi, 2004 2. Wakil MM, Power Plant Technology, McGraw Hill Book Co, New Delhi, 2004. 3. G. D. Rai Non – Conventional Energy Sources. Khanna Publication 4. S P Sukhatme and J K Nayak, Solar Energy, McGraw Hill Book Co, New Delhi 4^{th} Edition, 2017

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours					
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	Credit	
CHE 613	**COMBUSTION ENGINEERING**	PEL	3	0	0	3	3	
Pre-requisites: Process calculation, Material and energy balance, Engg. Mathematics, ODE, PDE, Numerical techniques, modelling simulation with computing skill using c and Matlab program			Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))					
			CT+MT+EA					
Course Outcomes	• CO1: Clean coal technologies, coal bed methane blending of biomass with coal. • CO2: Mass and energy balance during combustion of solid, liquid and gaseous fuel. • CO3: Reaction kinetics and mechanism of Pyrolysis, Combustion and gasification. • CO4: Burner design for different industrial application.							
Topics Covered	**Module I:** Properties of solid liquid and gaseous fuels Classification, Composition, Calorific Values, Lower and higher heating values, ASTM test techniques of solid, liquid and gaseous fuels. Gasification of coal –Coal gasification technologies, chemical reactions, process conditions, design of gasification equipment. Underground coal gasification technology, process route. Clean coal Technologies: What is clean coal technology? Principle and objectives.Oxyfuel combustion, Biochar, Carbon capture and storage, Carbon sequestration, Kyoto Protocol, Mitigation of global warming, Refined coal, Coal bed methane deposits, CBM recovery through microporous network, Primary method-Dewatering process, Secondary method (Carbon dioxide injection technique). [24 hrs.] Module II: Stoichiometry of combustion -							

	Chemical equations, Mass and energy balance of solid liquid and gaseous fuel combustion, concept of mixture fraction and equivalence ratio, problems on Fuel efficiency, excess air ratio and draft.Gas analyzers- Orsat and modern gas analyzers [7 hrs.] **Module III:** Combustion of liquid and gaseous fuels, Theory of diffusion flame, development diffusion flame equations and its solution technique, length of diffusion flame, chemical properties of diffusion flame & Premixed flame and its nature. Burner design for liquid and gaseous fuel, Types of Burners, design parameters and problems.[7 hrs.] **Module IV: 12h** Combustion of solid fuels, Stages of combustion- drying, devolatilization, volatile combustion, combustion of residual char, Pulverized coal combustion, Combustion in fluidized bed system, burning rate in fluidized bed, factors affecting combustion efficiency. Combustion in bubbling fluidized bed boilers Combustion mechanism dense phase and lean phase concept and mass and energy balance, Recirculation of fly ash, effect of design parameters on combustion efficiency. Single particle combustion modelling- Single particle combustion modelling using volume reaction model, reaction mechanism and role of pore surface area. Heat and species transport equation in porous medium.Excremental technique in TG/DTA and drop tube furnace. [24 hrs.] Tutorial and class test [5 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Combustion and Fuel Technology, A.K.Saha 2. Combustion and gasification in Fluidized bed, PrabirBasu, Taylor & Francis Suggested Reference Books: 1. Fundamentals of Combustion Engineering by Achintya Mukhopadhyay and Swarnendu Sen

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3		3					1	3	1
CO2	3	1	1		3			2				
CO3	3		3		3					1	3	1
CO4	1	3	3		3		1		1		3	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 614	**ARTIFICIAL INTELLIGENCE (AI) IN**	PEL	3	0	0	3	3

	PROCESS INDUSTRY						
Pre-requisites		Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	● CO1 : Acquire an idea about the application of artificial intelligence in chemical process industry ● CO2 : To learn the fundamental knowledge of Neural network base modeling and their application in chemical process industries ● CO3: To learn the fundamental knowledge of different stochastic optimization techniques and their application in industry
Topics Covered	**Module I:** Basic concept and introduction, Challenges faces by process industries, Paradigm shift of chemical business, What is artificial intelligence (AI)?, What is advance data analytics (ADA)?, Use of artificial intelligence (AI) and advance data analytics in different fields, Use of AI in chemical process industry and changing business scenario of chemical process industry , Areas where AI have impact on process industry, Different real life case studies of application of AI in process industry , How AI based techniques can be used to increase profit in chemical industry. [08 hrs.] **Module II:** Application of artificial neural network (ANN) for modeling industrial processes What is process modeling? ,Difference between process design and process simulation , Different process modeling strategy , Comparative advantage and disadvantage of different modeling strategy , Limitations of first principle base modeling , Limitations of commercial simulators to model complex industrial reactors ,Data driven black box or grey box modeling technique and its advantage ,Necessity to build a platform to utilize large number of process data , Artificial neural network (ANN) as effective tool of black box modeling, What is artificial neural network (ANN)?, Network architecture, Back propagation algorithm, How ANN can be used to develop complex industrial processes, Steps in ANN modeling technique ,Modeling of process performance parameters like selectivity, yield, efficiency etc. , Different examples of ANN modeling applied in diverse field of process industries, A step by step matlab based ANN case study for modeling of industrial reactor ,Different aspects of ANN modeling. [12 hrs.] **Module III:** Artificial intelligence based process optimization What is process optimization? , How parameter optimization can increase profit? , Limitations of conventional methods to apply complex industrial context, Use of metaheuristic method for optimization, Different Meta heuristics strategies like genetic programming, differential evolution and particle swarm optimization, Genetic algorithm (GA), what is GA? Basic algorithm and matlabcode ,Explanation of different parameters in GA algorithm ,Different uses of GA in various fields of process optimization , Differential evolution (DE), what is DE? Basic algorithm and matlabcode ,Explanation of different parameters in DE algorithm,Different uses of DE in various fields of process optimization

	Particle swarm optimization (PSO), What is PSO?, Basic algorithm and matlab code, Explanation of different parameters in PSO algorithm, Different uses of PSO in various fields of process optimization ,How metaheuristics algorithm can be used for parameter optimization,3 case study in reactor optimization, Advantage of metaheuristics methods over conventional methods. [10 hrs.] **Module IV:** Artificial intelligence based fault diagnosis in process industry Development of system to use and generate knowledge from process data ,Online advance process monitoring ,Generation of dashboard of different KPI ,Use of different advance computational technique to visualize data ,Artificial neural network based monitoring system ,How ANN can be used to develop advance process monitoring system ,Steps to develop ANN based process monitoring system Principal component based monitoring system, What is Principal component analysis (PCA)?, PCA algorithm, How PCA can be used to develop advance process monitoring system ,Advantage of PCA based monitoring system ,Steps to develop PCA based process monitoring system Development of Fault diagnosis system What is fault diagnosis system?, Features of fault diagnosis system ,How a robust fault diagnosis system can be made by PCA and ANN , Steps to build efficient fault diagnosis system ,Matlab code ,Case study. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Profit Maximization Techniques for operating Chemical Plants, Sandip Kumar Lahiri, Wiley, ISBN 978-1-119-53215-6 2. Process plant simulations, B.V. Babu ,Oxford University Press 2004 Suggested Reference books : 3. Energy and process optimization for the process industries By Frank (Xin X) Zhu (Wiley, ISBN 978-1-118-10116-2)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	2	2	2	2	2	1	1	2	1	2	2	1	2
CO2	3	3	3	2	3	2	1	3	1	3	3	1	3
CO3	3	3	3	2	3	2	1	3	1	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
		CA+EA					

Course Outcomes	• CO1:To make budding engineers aware of various management functions required for any organization • CO2:To impart knowledge on various tools and techniques applied by the executives of an organization • CO3:To make potential engineers aware of managerial function so that it would help for their professional career • CO4:To impart knowledge on organizational activities operational and strategic both in nature • CO5: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science
Topics Covered	**Module I:** Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning andenvironmental analysis with SWOT, Application of BCG matrix in organization [8 hrs.] **Module II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique [7 hrs.] **Module III:** Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. [8 hrs.] **Module IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. [8 hrs.] **Module V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. [12 hrs.]
Text Books, and/or reference material	<u>Suggested Text Books</u>: 1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. 2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education <u>Suggested Reference Books:</u>

	1. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 2. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey

Mapping of CO (Course Outcome) and PO (Programme Outcome)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	2	2	
CO2				2					2	2		
CO3				2					3	2		
CO4							1		3			
CO5				2					2	2	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH1003	**ADVANCED MATHEMATICAL METHODS FOR CHEMICAL ENGINEERING**	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
--		CT+EA					
Course Outcomes	• CO1: Conceptualization ofa chemical process and its calculation needs • CO2: Understanding the various equations for Estimation of Physical Properties and thermodynamic parameters • CO3: Understandingthe mathematical equations and their solution procedure related to fluid dynamics and Chemical reaction engineering • CO4: Calculations and their solution methodology related to mass transfer						
Topics Covered	**Module I:** Solutions of Algebraic Equations Truncation error, round-off, Chopping-off error, loss of significance and propagation of error. Jacobi and Gauss-Seidel iterations, Eigen value problem, Gauss elimination, Tri-Diagonal matrix, algorithm (TDMA), Applications-heat transfer, chemical reactions, fitting straight line and polynomial etc.						

	Newton-Rapson method, Newton's method, application in thermodynamic property calculation, bubble point calculations equations, stability analysis of a non-isothermal CSTR. [7 hrs] **Module II:** Solutions of Differential Equations ODEs-Euler's Method, Runge-Kutta Method, predictor-corrector method, Crank-Nicholson method Applications in chemical reaction Engineering and heat transfer [6 hrs] **Module III:** Solutions of Partial Differential Equations (PDE) Finite volume technique for PDE. Steady state convection diffusion equation, unsteady Steady state convection diffusion equation. PDE with linear and non-linear source terms [8 hrs] **Module IV:** Numerical methods with Matlab and Excel Introduction to MATLAB, Numerical Methods with MATLAB, Linear Systems, Nonlinear Equations, Regression Analysis, Interpolation., Optimization, Differentiation and Integration, Ordinary Differential Equations, Partial Differential Equations [5 hrs] **Module V:** Fluid Mechanics Friction Factor, Flow of Fluids in Pipes, Friction Loss, Overall Pressure Drop, Flow through Tank, Compressible Fluid Flow in Pipes, Two-Phase Flow in Pipes, [5 hrs] **Module VI:** Chemical Reaction Engineering Calculations and estimations of different parameters related to the following: Reaction Rates, Continuous-Stirred Tank Reactor (CSTR), Batch Reactor, Catalytic Reactors [5 hrs] **Module VII** Mass Transfer Multiple-Effect Evaporators, Shortcut Calculation Method for Multicomponent Distillation, Rigorous Steady-State Distillation Calculations [5 hrs] Tutorial on above topics, remedial classes and class tests. [14 hrs]
Text Books, and/or reference material	Suggested Text Books: 1.Chemical Engineering Computation with MATLAB., Yeong Koo Yeo, CRC Press 2. T.F.EdgarandD.M.Himmelblau,"OptimizationTechniquesforChemicalEngineers",McGraw-Hill,NewYork, 1985. 3.S. S. Rao,

	"EngineeringOptimizationTheoryandPractice",Thirdedition,NewAgeInternationalPublishers,India. 4. S. K. Gupta, "Numerical Techniques for Engineers",New AgeInternational Publishers, 3rd edition, 2015 5. Mathematical Methods in Chemical &Environmental Engineering: AjayK. Ray, ThomsonLearning,2000. Suggested Reference Books: 1. K. Deo,"OptimizationTechniques", WileyEastern, 1995. 2. R. Panneerselvam, "Operation Research", 2nd Ed., PHI Learning privateLtd, NewDelhi,India. 3.PremKumarGuptaandD.S.Hira "ProblemsinOperationsResearch(PrinciplesandSolutions)",S. Chand and company Ltd. NewDelhi,India.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	1	1
CO2	3	1	1
CO3	2	-	2
CO4	1	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHS 751</td><td>PROCESS CONTROL AND INSTRUMENTATION LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Process Control and Instrumentation</td><td colspan="5">CT and Viva-Voce</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the fundamental principles of process control through practical experimentation
• CO2: Handling various instruments and solve various difficulty levels</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Study the control valve flow coefficient (C_v) and its inherent characteristics.
2. Study the temperature control trainer and to find out steady state process gain.
3. Study the level control trainer and to find out steady state process gain.
4. Compare the observed transient response with the theoretical transient response for the interacting – non-interacting system.</td></tr>
</table>

	5. Study the step response of mercury manometer and water manometer. 6. Plot Bode diagram of manometer systems and design the controller using Z-N tuning method. 7. Study the root locus of a manometer and hence to determine the region of stability. [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 Edition (1991) 2. Chemical Process Control, G. Stephanopoulos, PHI, (2008) Suggested Reference Books: 1. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (1996)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2	1	2				1		2	
CO2	3		2	1	2				1		2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 752	**CHEMICAL ENGINEERING COMPUTING LABORATORY- 2**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHEMICAL ENGINEERING COMPUTING LABORATORY- 1 (CHS 351)		EA and Viva-Voce					
Course Outcomes	• CO1: To improve the skill of programming with numerical methods • CO2: To solve Chemical Engg problems using computers (using Matlab/Aspen/Ansys)						
Topics Covered	**Module I** 1. Arrays Operations, Loops in Matlab 2. Script and Functions in Matlab 3. Plotting in Matlab 4. Truncation Error and Numerical error in Matlab 5. Numerical Differentiation and Integration using Matlab						

	Module II Solving Linera/non-linear equations using Matlab Solving set of linear equation Solving ODEs in Matlab (RK/ODE45) **Module III** Intruduction to Matlab-Simulink Tuning of PID controller using Simulink Example cases using Simulink **Module IV** Introduction to Aspen-Plus Property analysis using Aspen-Plus Process Modelling and simulation using Aspen-Plus [36 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Computational Techniques for Process Simulation and Analysis Using MATLAB, Niket S. Kaisare, CRC Press 2. Teach Yourself the Basics of Aspen Plus, Ralph Schefflan, 2nd Edition, AIChE, Willey Suggested Reference Books: 1. Introduction to Simulink: With Engineering Applications,by Steven T. Karris, Orchard Pubns; 3rd edition

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2	1	2				1		2	
CO2	3		2	1	2				1		2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS 753	**COMPUTER-AIDED**	PCR	0	0	3	3	1.5

	PROCESS EQUIPMENT DESIGN						
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Process Equipment Design I & II		Report submission and Viva-Voce					
Course Outcomes	• CO1: Students are groomed to become confident design engineers / process simulators. They are also made conversant with all aspects of chemical engineering science, since development of CAD packages demands proficiency in all unit operations and unit processes.						
Topics Covered	1. Introduction to the basic principles of pressure vessel, Heat Exchanger, Evaporator and distillation process and its applications 2. Computer Aided process design of Pressure Vessel by Auto-CAD 3. Computer Aided process design of Heat Exchanger column by Auto-CAD 4. Computer Aided process design of Evaporator by Auto-CAD 5. Computer Aided process design of distillation column by Auto-CAD						
Text Books, and/or reference material	Suggested Text Books: 1. L. E. Brownell, E. H. Youg, "Process Equipment Design" John Wiley & Sons Publications, 2004. 2. J.M. Coulson and J. Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers Ltd. 3. Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, 1969. Indian Standards Institution, New Delhi. Suggested Reference Books: 1. R.H. Perry, "Chemical Engineers' Handbook", McGraw-Hill. 2. W.L. McCabe, J.C. Smith and P. Harriot, "Unit Operation of Chemical Engineering", McGraw-Hill, 2001.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	3	3	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS754	**VOCATIONAL TRAINING / SUMMER**		0	0	2	2	1

	INTERNSHIP & SEMINAR						
Course Outcomes		● CO1: Ability to understand all the Unit Operations and Unit Processes in real-life problem. ● CO2: Knowledge sharing					
Topics Covered		Industrial Training, Internship etc. 4 -8 weeks					
Text Books, and/or reference material		NA					

Seventh Semester Departmental Electives (CHE710-720)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 710	**ENERGY SOURCES AND UTILISATION**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	● CO1: Learn different sources of energy and basic terminology ● CO2: Identify characteristic properties of fuels and analyze fuel processing equipment ● CO3: Compare performances and select type of fuel processing equipment						
Topics Covered	**Module I:** Introduction: Survey of different sources of energy and their utilization. Fossil fuels: Coal, Petroleum and gaseous fuels. Coal: Origin and formation of coal . Petrographic constituents of coal, Properties and testing. Classifition of coal, Coal preparation- washing and blending, Metallurgical and other uses. Carbonisation of coal, coke ovens and recovery of by- products. [5 hrs.] **Module II:** Petroleum : Constitution of petroleum, Origin and Occurrence of crude, Evaluation of crude, Properties, testing and specifications of petroleum products- Octane no.; Reid vapor pressure; Flash point; Fire point; Smoke point; Pour point; Cloud point; Aniline point and Diesel index; Cetane no. , Processing of Crude Petroleum.[12hrs.] **Module III:** Gaseous fuels: Classification. Manufacture of producer and water gas. Combustion and furnace: Combustion characteristics, Combustion appliances--						

	furnaces, waste heat recovery system, burners. [11 hrs.] **Module IV:** Non-conventional energy sources: Solar energy, Wind, Tidal Energy, Wave Energy, Energy from biomass, [4 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Modern Petroleum Refining: B. K. B. Rao 2. Fuels & Combustion: Samir Sarkar Suggested Reference Books: 1. Petroleum Refining Engineering: W. L. Nelson 2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk 3. The elements of fuel technology: G. W. Himus

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 711	**BIOPROCESS & BIOREACTOR ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHC 301, CHC 403, CHC501		CT+MT+EA					
Course Outcomes	• CO1: Apply kinetics of biochemical reactions for design of bioreactor. • CO2: Analyze performance of ideal and non-ideal bioreactors. • CO3: Integrate different type of reactor and reactor assembly.						
Topics Covered	**Module I:** Introduction to the kinetics of Bioprocess; Free enzyme kinetics; Inhibition in enzymatic reactions. Kinetics of immobilized enzymes. Bioreactors for enzymatic reactions. [15 hrs.] **Module II:**						

	Cell growth kinetics; Growth models, Inhibition in cell growth kinetics, Immobilized cell growth system. Reactors for cell growth system. Combination of bioreactors for cell growth. [15 hrs.] **Module III:** Multiplicity in Biosystems, Global and local stability analyses of Bioreactors. Bioreactor controlling probes, Characteristics of bioreactor sensors, Temperature measurement and control, DO measurement and control, pH/redox measurement and control, Detection and prevention of the foam. [10 hrs.] **Module IV:** Downstream processing in bioprocesses; Intra and extracellular product extraction and separation. Industrial application of bioprocesses. [10 hrs.]
Text Books, and/or reference material	SuggestedText Books: 1. J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, Second Edition, Mc. Graw Hill Inc., Singapore, 1986. 2. H. W. Blanch, D. S. Clark, Biochemical Engineering, Special Indian Edition, Marcel Dekker Inc. New York, 2007. 3. M. L. Shuler, F. Kargi, Bioprocess Engineering - Basic Concepts, Second Edition, Prentice Hall of India Private Ltd., New Delhi, 2002. SuggestedReference Books: 1. P. M. Doran, Bioprocess Engineering Principles, Academic Press, California, 2009. 2. J. Nielsen, J. Villadsen, G. Liden, Bioreaction Engineering, Second Edition, Springer, 2007. 3. D. G. Rao, Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	1	1	2	2	2	3	1
CO2	3	2	3	2	3	1	1	2	2	2	3	1
CO3	3	2	3	2	3	1	1	2	2	2	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

CHE 712	PROCESS ENGINEERING	PEL	3	0	0	3	3
Pre-requisites Unit operations and Chemical reactor, Chemical Process Technology, Optimal design methods			Course Assessment methods (Continuous (CT) and end assessment (EA))				
		CT+EA					
Course Outcomes	● CO1: Understanding process design concepts ● CO2: To troubleshoot real-time chemical processes ● CO3: To do optimal plant operation						
Topics Covered	**Module I:** Introduction, Course objectives and course outcomes- Definition of process engineering–responsibilities of Process Engineers. Structure of Processes and Process Engineering [5hrs.] **Module II:** Process Design and Flow sheeting, Process design principles; process selection; Degree of freedom; selection of design variable; mass balance and energy balance; process flow sheeting; sizing of equipment. [12hrs.] **Module III:** Process dynamics and dynamic optimization: Process response and retrofitting; Dynamic models; Optimization models for process synthesis and design; dynamic optimization; real-time optimization;[12hrs.] **Module IV:** Process Synthesis :Basic concepts in process synthesis; flowsheet optimization and economic analysis; process trouble shooting; case studies, [12hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Rudd DF, Watson, CC. Strategies of process engineering, John Wiley, 1968 2. Seader WD, Seader, JD, Lewin, DR. Product & process design principles, John Wiley, 2004 Suggested Reference Books: 1. Arthur W. Westerberg, I.E. Grossmann, and Lorenz T. Biegler, Systematic Methods of Chemical Process Design. Prentice Hall						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1	1						1	
CO2	3		2								1	
CO3	3				1							1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

CHE713	CHEMICAL PLANT DESIGN AND ECONOMICS	PEL	3	0	0	3	3
Pre-requisites: Unit operations and Chemical reactor, Chemical Process Technology, Optimal design methods		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	• CO1:Managing various process design projects • CO2: Understanding process design concept based on mass-energy balance and optimization • CO3: Determining design-project feasibility and implementation time
Topics Covered	**Module I:** Plant Design life cycle: Various stages of a plant design project – managing the various stages of plant design project – various approaches. Various scheduling methods for plant design[10hrs.] **Module II:** Plant Design Projects: Process design principles; process selection-DOF-design variable; -mass balance and energy balance; flow sheeting; sizing of equipment; P&ID-basic engineering package (BEP); Principles of equipment layout in and site selection for chemical plants; Types and selection of materials of construction for process equipment. [12 hrs.] **Module III:** Feasibility of Plant Design**:**Estimation of cost and profit - taxes & depreciation-rate of return (ROI)-case studies; Screening of Process Alternatives; Concepts of investment, interest and time value of money; Profitability analysis. Analysis of alternative investments and replacements.[10hrs.] **Module IV:** Case studies :Design of Reactors; Design of Separation Processes; Energy Integration and Design of Heat Exchanger Network (Pinch Technology);[13 hrs.]
Text Books, and/or reference material	<u>SuggestedText Books</u>: 1. Peters, M S, Timmerhaus, KD, Plant Design and Economics, McGraw Hill, 1991 2. Towler G, Sinnott, Ray, Chemical Engineering Design, Elsevier, 2008 <u>SuggestedReference Books:</u> 1. Rudd DF, Watson, CC. Strategies of process engineering, John Wiley, 1968 2. Seader WD, Seader, JD, Lewin, DR. Product & process design principles, John Wiley, 2004.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1							1	1

CO2	3				1						1	1
CO3	3			1	1						1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engieering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 714	**PROCESS SAFETY IN CHEMICAL INDUSTRIES**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	•CO1: Understand the key principles of process safety and its management and consequences of poor process safety (human, environmental and business consequences) •CO2: Understand the hazards associated with process plant and how the risks can be controlled •CO3: Understand the key process safety requirements at each stage in the life cycle of process plant from conceptual design through to operation, maintenance and modification •CO4: Understand the interdependence and the need for overall organization process safety management capability						
Topics Covered	**Module I:** Introduction and Review of Industry Accidents, Basic Laboratory Safety and Bio-safety levels, Importance of personal protective equipment,[8 hrs.] **Module II:** Basics of process safety management,Toxicology and Industrial Hygiene, [7 hrs.] **Module III:** Source Models and Dispersion Models, Fire and Explosion, Designs to prevent fire Fire extinguishers and Sprinklers, Introduction to reliefs. [20 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Process Safety: Fundamentals with Applications: Daniel Crowl and Joseph F. Louvar, 3rd ed., Pearson New International Edition. Suggested Reference Books: 1. Safety in Chemical Plants/Industry & its Management, B. K. Bhaskara Rao, R. K Jain, Vineet Kumar, Khanna Publishers						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3	1	2	3		2	1	3	3	2
CO2	3		3	1	2	3		2	1	3	3	2
CO3	3		3	1	2	3		2	1	3	3	2
CO4	3		3	1	2	3		2	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC 715	**MEMBRANE SEPARATION PROCESS**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CHC 502		CT+MT+EA					
Course Outcomes	• CO1: Learn fundamentals of membrane separation processes and current market scenario • CO2: Classify and characterize membrane separation processes • CO3: Principles and methodologies of separation and transport of molecules through membrane and latest development • CO4: Complete process design of separation and exercise problems through tutorials/ assignment / group task						
Topics Covered	**Module I:** Membrane Separation Processes: Types of membranes and membrane characterization, Membrane modules and motion of molecules through membrane, Classification & characterization of Membrane Separation Processes. Reserve Osmosis (RO): Fundamentals, Osmotic Pressure, Models of Solvent and solute Transport through membrane – Fluxes, Rejection and Separation factor, Mechanism of salt rejection by CA membrane, Concentration Polarization, applications [12 hrs.] **Module II:** Nano-filtration (NF): Fundamentals of NF, Models and Types of transport mechanism in NF membranes, Applications of NF Ultra-filtration (UF): Models and Types of transport in UF membranes, Membranes for UF – Fouling and concentration Polarization in UF, Separation schemes using UF, Dia-filtration – process design – batch, continuous, multistage						

	Micro-filtration (MF): Membranes for MF – transport mechanism [12 hrs.] **Module III:** Dialysis: Solute transport in dialyzer – analysis of dialysis operation, Mode of dialysis, Hemo-dialysis – dialysis equipment – applications Electro –dialysis (ED): Types of ED – ion transport fundamentals, Resistances and voltages in ED cells – power requirement, ED membranes and cells, Problems of ED operation, Plant design and process cost. [8 hrs.] **Module IV:** Pervaporation (PV): Theory of PV – parameter study, Classification of PV – air heated PV, Osmotic distillation, thermo-pervaporation, Advantages and disadvantages of PV, Application of PV, Gas Separation: Membrane gas separation, Industrial applications. [8 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Separation Processes – C. J. King 2. Synthetic membranes – P. M. Bungay, H. K. Lonsdale, M. N. de Pinho Suggested Reference Books: 1. Membrane Separation Processes – KaushikNath 2. Membrane Hand Book – W. Ho and K. K. Sirkar 3. Industrial Processing with membranes – R. E. Lacey & S Loeb 4. Reverse Osmosis – S. Sourirajan 5. Ultrafiltration Handbook – M. Cheryan 6. Principles of Mass Transfer and Separation Processes – B. K. Dutta 7. Membrane Technology in Environmental Pollution Control, P.Pal 8. Industrial Water Treatment Process Technology, P.Pal, Elsevier Science 9. Membrane Technology in Environmental Pollution Control. P.Pal

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	2	2	2	1	2	2	1
CO2	3	2	3	2	2	1	1	2	1	2	2	2
CO3	3	2	3	2	2	2	1	2	2	1	1	2
CO4	2	3	2	1	2	1	1	3	2	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 716	**PROCESS**	PEL	3	0	0	3	3

	INTENSIFICATION						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Understanding the concept, need and benefits of process intensification amidst • stringent environmental regulations, concerns for energy security and sustainable • development • CO2: Learn different approaches of achieving process intensification • CO3: Learning design, operation, analysis and application of selected process intensification technologies						
Topics Covered	**Module I:** Basics of Process Intensification, definitions, routes, benefits, need for process intensification, sustainable development issues [4 hrs.] **Module II:** Twelve principles of green chemistry. Matrices for chemistry: Effective mass yield, carbon efficiency, atom economy, reaction mass efficiency, Environmental factor (E) [4 hrs.] **Module III:** Process Intensification by Multifunctional equipment, Principles, design, operation and case studies [4 hrs.] **Module IV:** Process Intensification by reactive distillation: Principles, design, control, feasibility, technical evaluation, case studies [4 hrs.] **Module V:** Process Intensification by catalytic distillation: Principles, design, operation, application, economics [4 hrs.] **Module VI:** Process Intensification by Membrane application: principles, modular design issues, energy saving prospects, space-saving prospects, green processing prospects, case studies [4 hrs.] **Module VII**: Case studies of process intensification in lactic acid manufacture, glutamic acid manufacture, industrial wastewater treatment and reuse, recovery of valuables. [6hrs.] **Module VIII:** Process Intensification through cavitation reactors, oscillatory baffled reactors, sono-chemical, hydrodynamic cavitation reactors, case studies [4 hrs.] **Module IX:**						

	Process Intensification through monolith reactors: Hydrodynamics, design, advantages, applications [4 hrs.]
Text Books, and/or reference material	Suggested Text Book: 1. Intensification of bio-based processes, A. Gorak, Andrzej Stankiewicz edited. RSC publication 2. A.Stankiewicz, J.A. Moulijin, Re-engineering the Chemical Processing Plant, Process intensification, Marcel Dekker, New York (2004) Suggested References Book: 1. Membrane based technologies for environmental pollution control, P.Pal, Elsevier Sci.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 717	**COLLOIDS AND INTERFACE ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Acquire an idea about the application of colloidal chemistry, fluid-fluid and solid-fluid interface engineering in different industrial fields. • CO2: To learn the fundamental knowledge of intermolecular forces involved in colloids and interfaces • CO3: Introduction to surface active agent and learn about the application of surface active agents to enhance the efficiency in the process.						
Topics Covered	**Module I:** Importance and scope of the subject. Overview of colloidal systems, interfaces and surface. Properties and application of the colloids. Colloidal stability factor. Kinetic theory of						

	colloidal systems: sedimentation, centrifugation, diffusion, Domestic and industrial application of colloidal solution. Adsorption at fluid-fluid and fluid-solid interface, Thermodynamics of interfaces, Interfacial rheology and transport process.[10hrs.] **Module II:** Surface active agent: Surfactant, Surface and interfacial tension, surface free energy. Surface tension for curved interfaces, Surface excess and Gibbs equation. Theory of surface tension, contact angle, and wetting. Thermodynamics of micelle and mixed micellar formation. Adsorption of single and mixed surfactants at interfaces, Mixed micellar properties, Rheology of surfactant systems. Preparation, mechanistic details of stabilization and relationship between HLB and solubility parameter, characterization and Application. [10hrs.] **Module III:** Intermolecular forces relevant to colloidal systems: Electrostatic and van der Waals forces. DLVO theory.Measurement techniques of surface tension, contact angle, zeta potential, particle size.[4 hrs.] **Module IV:** Overview of industrial applications of various interfacial phenomena in the industries [Mattress industry (Foam: preparation, characterization, stability), petroleum industry, Mineral processing industry Pesticides, firefighting, personal care formulations], Super hydrophobic surface and self-cleaning surfaces. Case studies related interfacial science. Application of interfacial engineering concept through the surface modification for the synthesis of nanostructured material by using surface active agent.[12hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. P. C. Hiemenz, and R. Rajagopalan, Principle of colloid and surface chemistry, 3rd edition, MercelDekher, N. Y. 1997. 2. Pallab Ghosh, Colloid and Interface Science, 1st Edition, PHI Learning, 2009. 3. M. J. Rosen, Surfactants and Interfacial Phenomena, Wiley-Interscience Publication, New York, 2004. Suggested Reference Books: 1. Drew Myers, Surfaces, Interfaces and Colloids, 3rd Edition, Wiley, 2006. 2. Tharwat F. Tadros, Applied Surfactants Principles and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2005. 3. J. Israelachvili, Intermolecular and Surface Forces, Academic Press, New York, 1992.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3							2				1

CO2			2		2							1
CO3		2	2					2				

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Chemical Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHE 718</td><td>PINCH TECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Heat Transfer</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire an idea to optimize the process heat recovery and reducing the external utility loads.
CO2: To achieve financial saving by constructing the best process heat integration.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I:
Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram. Introduction to Pinch Technology, Conceptof ΔT_{min}, Data Extraction, Composite curve, Grand Composite Curve Targeting, Grid Diagram, Problem Table Algorithm. [4 hrs.]
Module II:
Energy Targeting, Area Targeting, Number of units targeting, Shell Targeting and Cost targeting.[8hrs.]
Module III:
Pinch Design Methods of HEN, Heuristic rules, stream splitting, and design of maximum energy recovery (MER). Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems and design strategy. Network evolution and evaluation-identification of loops and paths, loop breaking and path relaxation.[10hrs.]
Module IV:
Design tools to achieve targets, driving force plot, remaining problem analysis, diverse pinch concepts, MCp ratio heuristics. Targeting and designing of HENs.[4 hrs.]
Module V:
Case studies on heat integration by pinch technology. [8hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Shenoy U. V.; "Heat Exchanger Network Synthesis", Gulf Publishing Co.
2. Smith R.; "Chemical Process Design", McGraw-Hill.
3. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of</td></tr>
</table>

	Energy", Inst. Of Chemical Engineers. Suggested Reference Book: 1. Ian C. Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, 2nd Edition, ISBN: 9780750682602, Butterworth-Heinemann, 2016.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	1	1	3	2	3	3	2
CO2	3	3	3	3	3	1	1	3	2	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 719	**ENERGY MANAGEMENT AND PROCESS OPTIMIZATION IN CHEMICAL INDUSTRIES**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire an idea about the energy intensity in industry context and benchmarking energy intensity • CO2: To learn the step by step methodology for energy assessment in industry, finding optimization opportunities and how to exploit them in industry. • CO3: To learn the fundamental knowledge of different Process optimization techniques to increase profit						
Topics Covered	**Module I:** Basic concept and introduction Challenges faces by process industries ,Paradigm shift of chemical business ,Background of energy and process optimization in industry ,Five ways to improve energy efficiency , Four key element for continuous improvement , Theory of energy intensity ,Definition of process energy intensity ,Concept of fuel equivalent ,Energy intensity for a total site, Benchmarking energy intensity, Data extraction from historian ,Convert all energy usage to fuel equivalent ,Energy balance, Energy performance index method ,Key indicators and targets ,Define key indicators, Set up targets for key indicators, Economic evaluation of key indicators ,Implementing key indicators into energy dashboard.						

	[10hrs.] **Module II:** Pinch Technology for heat exchanger network, Basic concept of pinch, Hot and cold composite curve, Pinch temperature, Golden rules of pinch, cross pinch heat transfer, Minimum hot and cold utility target, Optimum delta T min. [12hrs.] **Module III:** Heat exchanger Distillation system performance assessment, Basic concept and calculations, understanding performance criteria –U values, understanding pressure drop,Improving heat exchanger performance, Heat exchanger fouling assessment,Fouling mechanism, Fouling mitigation,Fouling resistance calculations,A cost based model for clean cycle optimization,Energy loss assessment, Energy loss audit, Energy loss evaluations,Brainstorming, Energy audit report, Distillation system assessment Distillation operating window,Distillation efficiency,Understanding operating window,Typical capacity limit, Distillation system optimization, Define a base case,Building process simulation, Tower efficiency assessment,Tower optimization basis,Energy optimization for distillation system,Overall process optimization. [10hrs.] **Module IV**: Process optimization in industryCollect online data for the whole operation cycle, Determine the true benefit from process variation, Map the whole process in cost term,How to detect opportunities for optimization,Common tools available to exploit those opportunities. [12hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Energy and process optimization for the process industries By Frank (Xin X) Zhu (Wiley, ISBN 978-1-118-10116-2) 2. Profit Maximization Techniques for operating Chemical Plants, Sandip Kumar Lahiri, Wiley, ISBN 978-1-119-53215-6 Suggested Reference books: 1.Process Heat Transfer – D.Q.Kern (McGraw-Hill)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1	PO12	PO13
CO1	2	2	2	1	2	1	1	2	1	2	2	1	2
CO2	3	3	3	2	3	2	1	3	1	3	3	1	3
CO3	3	3	3	2	3	2	1	3	1	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) /	Total Number of contact hours				Credit
			Lectur	Tutorial	Practical	Total	

		Electives (PEL)	e (L)	(T)	(P)	Hours	
CH 720	**SELF-MASTERY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Midterm (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1:To expose to a wide variety of techniques and exercises that have been found to be helpful in sparking the creative process; to help you select those that best fit your personality and apply them to many different business and personal situations. • CO2:To help you discover your "purpose in life", the grand design that gives meaning to all of your activities; to help you find that to which you can enthusiastically devote the rest of your life. When you are moved by deep inner conviction is when you have the greatest opportunity to sway others, in short to become a "leader". • CO3:To show you how you can mobilize resources to reach your goals most efficiently. There is a non-linear relationship between "work" and "results". Immense exertion can produce little outcome and, at other times, a little effort can yield a huge payoff. If you have an open mind you can learn to create serendipitous opportunities.
Topics Covered	**Module I:** Mental Models and How You Became What You Are Your Starting Point,What Is A Mental Model?, It's Not Real! It's Only a Model, Why And How You Became Who You Are, Good Thing, Bad Thing - Who Knows?, When Does Suffering Begin?, Taming The Horse – It Isn't Easy, But It Can Be Done, Dropping the Baggage, Be A Daruma Doll. [8 hrs.] **Module II:** How to Win the Inner Game Of Happiness Shape Your World By Being Observant, Turn Difficult Situations Into a Game, How Attitude Molds Your Blessings, Quick Trick That Beats Positive Thinking, How To Use Affirmations Effectively, Build a Daily Gratitude Practice, How to Get Off the Hedonic Treadmill, Overcome the Life of Quiet Desperation, Discover the Secret to Happiness, Achieve Great Success Beyond Your Dreams, Unravel Your Mental Chatter, Learn to Tame Your Mental Chatter, Successfully Implement Positive Chatter, Master the Skill of Managing Yourself, Become the Best Actor in Your Life Play, Simple Trick to Eliminate Stress, Identify Your True Self Through Consciousness, How Did The One Become Many?, How to Be of Greater Service to Others. [12 hrs.] **Module III:** Your Future Depends On Thinking Big and Why Mindfulness Matters Overcome the Need to Compare, Learn to Let Go of Possessions, What Does Your Ideal Day Look Like?, Move From Burden to Freedom, How to Read Another Person Through Conversation, Turn Your Question Into an Answer, Switch Sense of Injustice Into Awakening, What Is the Root of All Your Problems?, Shift from Me-Centered to the Other-Centered Universe, Change the Stories That Don't Serve You, Learn to Respond with Care, What to Do When Fear Strikes,Where Does Your Journey Take You?, Create Paradigm Shift in Your Consciousness, Who Are You Being?, Master Life

	on Two Simultaneous Levels, How to Set Goals. [10 hrs.] **Module IV:** 10 habits to make you highly effective in your life How habits define your success, Paradigm shift, Habit 1: Be Proactive Focus and act on what you can control and influence instead of what you can't. Habit 2: Begin With the End in Mind® Define clear measures of success and a plan to achieve them. Habit 3: Put First Things First® Prioritize and achieve your most important goals instead of constantly reacting to urgencies. Habit 4: Think Win-Win® Collaborate more effectively by building high-trust relationships. Habit 5: Seek First to Understand, Then to Be Understood® Influence others by developing a deep understanding of their needs and perspectives. Habit 6: Synergize® Develop innovative solutions that leverage differences and satisfy all key stakeholders. Habit 7: Sharpen the Saw® Increase motivation, energy, and work/life balance by making time for renewing activities. Habit 8 : Help others to win their battle Habit 9 : Choose happiness over success Habit 10 : Build your own definition of success and happiness, [12 hrs.]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Seven Habits of Highly Effective People, Stephen R Covey 2. Happiness at Work: Be Resilient, Motivated, and Successful - No Matter What ,by Srikumar S. Rao <u>Suggested Reference books:</u> 1. Are You Ready to Succeed?: Unconventional strategies for achieving personal mastery in business and in life, by Srikumar Rao

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	1	2	3	3	1	2	3	2	3	2	1	1	1
CO2	1	2	3	3	1	2	3	2	3	3	1	1	1
CO3	1	2	3	3	1	2	3	2	3	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EIGHTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CH 2001	**ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Basic and Undergraduate level Engineering Thermodynamics course	CT+EA

Course Outcomes	• CO1: To learn the application of equation of state for ideal and non-ideal gases, and exergy analysis of chemical processes • CO2: To learn various fundamental property relations and their application to estimate thermodynamic parameters • CO3: To learn the thermodynamics of fluid phase equilibria • CO4: To learn the statistical interpretation of distribution function for measurement of interactions and surface forces.
Topics Covered	**Module I:** Review of laws of thermodynamics, Equations of state for ideal and non-ideal gases, Kammerlingh-Onnes equation, Van der Waals equation, Redlich-Kwong equation, Peng-Robinson equation, Bennedict-Webb-Rubin equation, Law of corresponding states, Acentric factor, Virial and cubic equation of state for binary mixtures, Exergy of heat, Exergy analysis of Chemical Engg Processes. Entropy and estimation of entropy changes. [7 hrs] **Module II:** Maxwell's relations, Clausius Clapeyron equation, Gibbs-Helmhotz equation, TDS equations, Heat capacity relations, Isothermal compressibility, Volume expansivity, Joule-Thomson coefficient. Residual properties: Estimation of residual parameters from virial and cubic equation of state, Fugacity and fugacity coefficient: Fugacity coefficient from compressibility factor, cubic and virial equation of state, Effect of temperature and pressure on fugacity. [6 hrs] **Module III:** Thermodynamics of fluid phase equilibrium: Partial molar properties, Chemical potential, Activity and activity coefficients, their evaluation, Gibbs–Duhem equation, Fugacity in mixture, Excess functions, Ideal solution, Lewis-Randall rule, Phase equilibrium for Multi-component system, Vapour-liquid equilibrium, Excess Gibb's free energy model: Wilson equation, NRTL equation, UNIFAC (Universal Functional Activity Coefficient) method, van Laar theory, Scatchard-Hildebrand theory, Flory-Huggins theory, Liquid-Liquid equilibrium, Solid-Liquid equilibrium. [10 hrs] **Module IV:** Multi-reaction stoichiometry, Equilibrium criterion of Chemical Reaction, Equilibrium

	constant, Van't Hoff's equation, Homogeneous gas-phase and liquid-phase reaction, Heterogeneous reaction equilibria, Fuel cell. [7 hrs] **Module V:** Statistical Thermodynamics: Thermodynamic ensemble; Most probable thermodynamic distribution function; Canonical, grand canonical and micro-canonical ensemble partition functions; Derivation of thermodynamic variables from partition functions; Statistical explanation of second and third laws of thermodynamics; Quantum statistics; Maxwell Boltzmann statistics, Fermi-Dirac statistics, and Bose-Einstein Statistics; their distributions; [12 hrs] Tutorial on above topics, remedial classes and class tests. [12 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Smith, J.M., Van Ness, H.C., and Abbott, M.M. "Introduction to Chemical Engineering Thermodynamics", 7th Edition., McGraw-Hill 2. Halder, G., Introduction to Chemical Engineering Thermodynamics, 2nd edition, 2013, PHI Learning Pvt. Ltd, New Delhi Suggested Reference Books: 1.Thipse, S.S. "Advanced Thermodynamics", Narosa Publishing House, New Delhi. 2.Thermodynamics and Introduction to Statistical Mechanics, B. Lindner, Wiley Interscience, 2004

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	2
CO3	3	1	2
CO4	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Background Core (BC) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH 2002	**ADVANCED TRANSPORT PHENOMENA**	BC	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Basics of Fluid Mechanics, Heat Transfer and Mass Transfer	CT+EA
Course Outcomes	• CO1: To create an understanding on universal approach of transportphenomena andfundamental transport processes like mass, momentum andenergy. • CO2:To give an understanding on shell balance technique, setting ofboundaryconditions etc.fordifferentgeometryofasystem. • CO3: To apply NSE, equation of continuity, equation of energy etc. to different types of geometrical systems. • CO4:Tosolveproblemsonmass,momentumandenergytransportusing transport phenomena approach.
Topics Covered	**Module I:** Transport Phenomena-an universal approach, Reynold transport theorem, Fundamental transport Processes and their relation. [3 hrs] **Module II:** Momentum transport phenomena: Idea about Shell balance technique and its application in rectangular, cylindrical and spherical coordinate systems. Navier-stokes equation (NSE), Euler equation, application of NSE in rectangular, cylindrical and spherical coordinate systems. Flow through parallel plates, flow over flat plates, Steady and unsteady systems, turbulent flow [12 hrs] **Module III:** Energy transport: Basic energy transport equations, application of equation of energy for analyzing different heat conduction, convection and reactor systems, steady state and unsteady state systems, simultaneous energy and mass transport system [12 hrs] **Module IV:** Mass transport: Types of fluxes and their relation, continuity equation for a binary mixture, application of equation of continuity for different coordinate systems, steady and unsteady state systems, diffusion in porous catalyst with and without chemical reaction, diffusion in falling liquid film, turbulent mass flux, interphase mass transport. [12 hrs] **Module V:** Transport phenomena in small and large scale systemsand their application. [3 hrs] Tutorial on above topics, remedial classes and class tests. [14 hrs]
Text Books, and/or reference material	Suggested TextBooks: 1. Analysis of Transport Phenomena by William M. Deen, Oxford Univ Pr; 2nd Edition, 2011. 2. TransportPhenomenabyBird,Stewart&Lightfoot,Wiley,2nd Edition,2010. Suggested ReferenceBooks: 1.Transport Phenomena: A Unified Approach by Brodkey& Hershey, McGraw-HillChemical EngineeringSeries,BrodkeyPublishing,2003 2. Transport Phenomena: An Introduction to Advanced Topics, Larry A. Glasgow, Wiley, July 2010.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	1	-	3
CO2	1	2	3

CO3	1	-	3
CO4	1	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

8th Semester Departmental Elective

Department of Mechanical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE810	**MULTIPHASE FLOW**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CHC-303 (Fluid Mechanics)		CT+EA					
Course Outcomes	• CO1: To learn fundamental and modeling methods of multiphase flow • CO2: To learn transport mechanism of multiphase flow and industrial application of multiphase flow • CO3**:** To learn differentflow patterns and flow pattern maps and measurement methods in multiphase flow.						
Topics Covered	**Module I:** Introduction to multiphase flow: Two phase flow: Gas/Liquid and Liquid/liquid systems: Flow patterns in pipes, analysis of two phase flow situations, Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction. [7hrs.] **Module II:** Flow Models:Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models -correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows Introduction to three phase flow. [10hrs.] **Module III:** Design and Stability of multiphase system:Dynamics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Flow regimes, pressure drop, holdup, distributions, mass and heat transfer, reactions, Applications of these contactors. [10hrs.] **Module IV:** Measurement techniques for multiphase flow:Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry). [10hrs.]							

	Module V: Hydrodynamics of three phase systems:An introduction of three phase flow; liquid – solid flow, gas-solid flow; liquid-liquid-gas flow; gas-liquid-solid flow; principle of hydraulic and pneumatic transportation; flow regime identification; related measurement techniques. [5hrs.]
Text Books, and/or reference material	Suggested Text Books 1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 1978. 2. Y. T. Shah, Gas-Liquid-Solid reactors design, McGraw Hill Inc, 1979 3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 1998 4. Govier, G. W. and Aziz. K., "The Flow of Complex Mixture in Pipes", Van Nostrand Reinhold, New York, 1972. Suggested Reference Books 1. Wallis, G.B., "One Dimensional Two Phase Flow", McGraw Hill Book Co., New York, 1969. 2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998 3.Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003 Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York. 1998.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		1		1					1		
CO2				1				1		1		
CO3	3		1	1		1		1	1	1		

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 811	**PROCESS ANALYSIS AND OPTIMIZATION**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC01, MAC02, CHS351		CT+MT+EA					
Course Outcomes	• CO1: Conceptualization of a chemical process and its needs • CO2: Solving material and heat balance for a large-scale process • CO3: Understanding process synthesis • CO4: Solving optimal design and control problems simultaneously						

	• CO5: Real time optimization techniques and their implementations
Topics Covered	**Module I:** Cramer's rule, Inverse of matrix, Gauss elimination, Gauss Jordan method, LU decomposition, Gauss Seidel method, error analysis, Linear regression. [9hrs.] **Module II:** Bisection method, successive substitution method, Newton-Raphson method, Secant method, Eigen values, Eigen vectors and its application in solving differential equations. [10hrs.] **Module III:** Multi-variable optimization algorithms: Unidirectional search, Direct search methods, Gradient based methods, Constrained optimization algorithms: Kuhn-Tucker conditions, Transformation methods. [8 hrs.] **Module IV:** Sensitivity analysis, Direct search for constrained minimization, Linearized search techniques, Feasible direction method, Generalized reduced gradient method, Gradient projection method. [6hrs.] **Module V:** ODE- Initial Value Problem, Boundary Value Problem, Specialized algorithms: Integer programming, Geometric programming, Nontraditional optimization algorithms: Genetic algorithms, Simulated annealing, Global optimization. [5hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Steven C. Chapra& Raymond P. Canale, "Numerical methods for engineers" McGraw-Hill, Sixth Edition 2. S. K. Gupta, "Numerical Techniques for Engineers", New Age International Publishers, 3rd edition, 2015 3. Deb K., Optimization for engineering design, Algorithms and examples, Prentice Hall of India, New Delhi, 2005. Suggested Reference Books: 1. S. Dutta, "Optimization in Chemical Engineering", Cambridge University Press, 2017 2. Mathematical Methods in Chemical & Environmental Engineering: Ajay K. Ray, Thomson Learning, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1		3			2	2		3	
CO2	3	1	1		3			3	1		2	
CO3	3	1	1		3			3	1		2	
CO4	3	1	1		3			3	1		2	

CO5	3	1	1		3			3	1	2	2	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 812	**BOILING HEAT TRANSFER**	PEL	3	0	0	3	3
Pre-requisites: Mathematical methods, Transport Phenomena, Heat transfer		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	• CO1: Concept of a vapor bubbles • CO2: Understanding micro-convection of heat • CO3**:** Computing boiling regimes and heat transfer coefficients
Topics Covered	**Module I:** Concept of a vapor bubbles :Boiling; Bubbles; growth mechanisms; modeling issues for pool boiling and flow boiling. [10hrs.] **Module II:** Boiling regimes and heat transfer coefficients Various boiling regimes; determination of heat transfer coefficients; subcooled boiling; saturated/bulk boiling; [10hrs.] **Module III:** Interfacial Instabilities and Flow Instabilities in Boiling Types of interfacial instabilities and flow instabilities; their mechanisms; consequences. [10hrs.] **Module IV:** Condensation: Collapse of vapor bubbles; their mechanism; condensation heat transfer coefficients.[10hrs.] **Course Assessment Method:** The theory performance of students are evaluated
Text Books, and/or reference material	Suggested Text Book: 1. John G. Collier, John R. Thome, Convective Boiling and Condensation, Clarendon Press, 1994 2. L S Tong , Y S Tang, Boiling Heat Transfer And Two-Phase Flow, CRC Press, 1997 Suggested Reference Book: 1. R.T. Lahey, Boiling Heat Transfer, ELSEVIER, 1992

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1						1	
CO2	3	2	1	1	1						1	

CO3	3	2	1	1	1						1	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 813	**CFD APPLICATIONS IN CHEMICAL ENGINEERING**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC 331, CHC 303		CT+MT+EA					

Course Outcomes	• CO1: To learn basics of continuum-based modelling and simulation; Its area of applications and limitations • CO2: To learn different discretization methods of continuum based governing equations • CO3: To learn different steps of CFD simulations • CO4: To learn the use of CFD techniques in realistic problems
Topics Covered	**Module I:** Introduction to Computational Fluid Dynamics Conservation Equations, Discretization. Different Numerical methods and their comparison; Finite Difference Method, Finite Volume Method, Finite Element Method, etc. Source terms and their linearization, Solution of discretized equations. [12hrs.] **Module II:** Solution of mass and energy equations:Solution of diffusive problems: Steady 1D, Steady 2D and Steady 3D problems. Unsteady 1D, 2D unsteady and 3D unsteady problems, Solution of convective-diffusion problems: Steady and unsteady problems; Different schemes, [18hrs.] **Module III:** Solution of momentum equations:SIMPLE, SIMPLER, SIMPLEC algorithms [10hrs.]
Text Books, and/or reference material	Suggested Text Books: 1.Numerical heat transfer and fluid flow by S.V. Patankar, Hemisphere Publishing Corporation, 1980. 2.Introduction to Computational Fluid Dynamics by Anil W. Date, Cambridge University Press, 1st Edition, 2005. Suggested Reference Books: 1. Computational Fluid Dynamics and Heat Transfer by P. S. Ghosh Dastidar, Cengage India Private Limited

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			3			2			3	

CO2	3	2			3						3	
CO3	3	3			3						3	
CO4	3	3			3			2		2	3	

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHE 814	**NANOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	● CO1: Acquire the concept of nanotechnology at the basic level to apply for different application. ● CO2: Acquire the concept of synthesis and characterization of nanomaterials. ● CO3: Acquire the idea how to apply nanotechnology in different fields (catalysis, energy and environment) for better efficiency.						
Topics Covered	**Module I:** Introduction to the physics of solid state. Structure and bonding elements of nanoscience & nanotechnology.[8hrs.] **Module II:** Synthesis of nanomaterials: General Top Down and Bottom up approaches. Physical Methods, Chemical Methods & Biological Methods. Mechanical, Structural, Thermal, Electrical & Optical properties.[10hrs.] **Module III:** Characterization techniques of nanomaterials: Spectroscopy, XRD, BET, TGA, SEM and TEM. Some special nanomaterials: Carbon nanotubes, Porous silicon, Zeolites, Aerogels, Core-shell, Hollow and Yolk-shell nanoparticle.[12hrs.] **Module IV:** Application of the nanomaterials in different fields.Nanolithography, Nanocomposites, Nanoparticles as catalyst, Nanoparticles in energy and environment application, Nanoparticles in biomedical application.[12hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. T. Pradeep, Nano: The Essentials, Understanding Nanoscience and Nano Technology, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007. 2. Nanotechnology: Principles & Practices; S. K. Kulkarni, Capital Publishing Company, Kolkata Suggested Reference Books**:** 1. Principles of nanotechnology: N. Phanikumar; Scitech, Kolkata 2. Introduction to nanotechnology: Charles P. Poole & Frank Li Owens, Wiley						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3			1	2							
CO2		2										2
CO3			3		2			3				

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

NINETH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH 1002	**CHEMICAL REACTOR ANALYSIS AND DESIGN**	PCR	3	1	0	4	4
Pre-requisites: Reaction Engineering		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	• CO1: To design & analyse ideal and non-ideal homogeneous reactors. • CO2: To design & analyse fluid-solid catalytic, non-catalytic and multiphase reactors. • CO3: To analyse thermal instability of reactors. • CO4: To design and analyse bioreactors.
Topics Covered	**Module I:** Ideal Reactors: Design and analysis of isothermal and non-isothermal batch, plug flow and backmix reactors. [8 hrs] **Module II:** Non-catalytic Fluid-solid Reactors: Shrinking core model. Design and analysis of non-catalytic fluid-solid reactors. [4 hrs] **Module III:** Fluid-solid Catalyzed Reactors: Catalysis, interaction of physical and chemical rate processes in a porous catalyst particle, effectiveness factor, selectivity. Design and analysis of Packed-bed, Moving-bed and Fluidized-bed reactors. [9 hrs] **Module IV:** Multiphase Reactors: Design and analysis of slurry and trickle bed reactors. [7 hrs] **Module V:** Multiple Steady States and Thermal Instability of Reactors; Dynamic analysis of CSTR; Sustained oscillation and limit cycle. [4 hrs] **Module VI:** Non-ideal Reactors: Residence time distribution of fluid in vessels, RTD in ideal and non-ideal reactors, Modelling of non-ideal reactors – Segregation model, Tanks-in-series model and Dispersion model. [5 hrs] **Module VII:** Biochemical Reactors: Enzyme-catalyzed and biomass growth reaction kinetics. Design of bioreactors. [5 hrs]

	Tutorial on above topics, remedial classes and class tests. [14 hrs]
Text Books, and/or reference material	Suggested Text books: 1. H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall. 2. O. Levenspiel, Chemical Reaction Engineering, John Wiley. Suggested Reference book: 1. Chemical Reactor Analysis and Design - G F Froment & K B Bischoff, John (Wiley).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	3	1	3
CO2	3	1	3
CO3	3	1	3
CO4	3	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Elective Bucket for Depth Elective 6 (Semester 8th) and Elective 7 (Semester 9th)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit (C)
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH 9011	**BIOCHEMICAL AND BIO-ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites: Basics of Reaction Engineering			Course Assessment methods (Continuous (CT) and end assessment (EA))				
--			CT+EA				
Course Outcomes	• **CO1:** To understand the basic kinetics of enzymatic and cell growth bioprocesses. • **CO2:** To apply the knowledge to design the bioreactor and analyze the reactor operations • **CO3:** To Evaluate industrial application and Economics of the process.						
Topics Covered	**Module I:** Introduction to Microbiology, Biochemistry and Bioproducts. Stoichiometry and Thermodynamics of biochemical reactions. [7 hrs] **Module II:**						

	Kinetics of homogeneous chemical reactions. Different types of bioreactors and reactor analysis. [7 hrs] **Module III:** Kinetics of enzyme catalyzed reactions using free enzymes. Kinetics of enzyme catalyzed reactions using immobilized enzymes. [7 hrs] **Module IV:** Kinetics of substrate utilization, product formation and biomass production of microbial cells. Kinetics of substrate utilization, product formation and biomass production of microbial cells [7 hrs] **Module V:** Transport phenomenon in bioprocess. Air and medium sterilization. [7 hrs] **Module VI:** Operation and Process control, Downstream processing, Economic analysis of biochemical processes. [7 hrs]
Text Books, and /or reference material	Suggested Text Books: 1. Dutta, R. Fundamentals of Biochemical Engineering. Springer Publications, 2008. Suggested Reference Books: 1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, NY: McGraw-Hill, 1986.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	2	2	2
CO2	2	3	3
CO3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9012	**ADVANCED**	PEL	3	0	0	3	3

	PROCESS DYNAMICS AND CONTROL						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	• CO1: Determiningthe controlstructures in chemical processes • CO2: Understandingmultiple MIMO systems and their dynamical interactions • CO3: Understanding the working of Model Predictive Control (MPC) • CO4: Awareness of different implementations steps of MPC in industry • CO5: Determiningthe controller settingsforMIMO systems.
Topics Covered	**Module I:** SISO control system Purpose of Process Control in Chemical Process Industries (CPI), Basic Feedback control loop, Control hardware; Process dynamics, Regulatory PID Control Layer, Advance Regulatory Control (ARC) Layer, Basis of cascade control, Ratio control, Feedforward control, split range control, Shortcomings of Simple Regulatory PID Control [10 hrs] **Module I:** Model Predictive Control (MPC) and MIMO control system MIMO control systems, Basic concept of Multivariable Model Predictive Control, Function of Multivariable Model Predictive Optimizing Controller, Relevance of Multivariable Predictive Control (MPC) in Chemical Process Industry in Today's Business Environment, Position of MPC in Control Hierarchy, Advantage of Implementing MPC, How Does MPC Extract Benefit? Application of MPC in Oil Refinery, Petrochemical, Fertilizer, and Chemical Plants, and Related Benefits [10 hrs] **Module III:** Theoretical base of Model Predictive Control (MPC) Concept of Controlled variables, manipulated variables and Disturbance variable, Features of MPC, Brief Introduction to Model Predictive Control Techniques, Simplified Dynamic Control Strategy of MPC, Historical Development of Different MPC Technology [10 hrs] **Module IV:** MPC Implementation Steps Preliminary Cost–Benefit Analysis, Assessment of Base Control Loops, Functional Design of Controller, Conduct the Preliminary Plant Test (Pre-Stepping), Conduct the Plant Step Test, identify a Process Model, Perform Offline Controller Simulation/Tuning, Commission the Online Controller, Online MPC Controller Tuning, Hold Formal Operator Training, Performance Monitoring of MPC Controller, Maintain the MPC Controller, Summary of Steps Involved in MPC Projects with Vendor [10 hrs]

Text Books, and/or reference material	Suggested Text Books: 1. SK Lahiri, Multivariable predictive Control-Applications in industry, Wiley. 2. P. K. Sarkar, AdvancedProcess Dynamics andControl, Prentice-HallofIndia Pvt. Ltd. 3. D.E.Seborg, T.F. Edgar,E.A.Mellichamp, F. J. Doyle, Process Dynamicsand Control, 3rd edition, John Wiley &Sons, NY. Suggested Reference Books: 1. B.A. Ogunnaike and W.H. Ray, 1994, Process Dynamics, Modeling,andControl, Oxford University Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	2	2	2
CO2	2	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9013	**ENVIRONMENTAL ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic subjects of Chemical Engineering and Mathematics		CT+EA					
Course Outcomes	● CO1: To illustrate the fundamental concepts in environmental engineering dealing with water, air, and land pollution ● CO2: To illustrate different techniques as used for treatment of wastewater with special emphasis on design, operational features, etc ● CO3: To design and analyse the equipment as used for removal of particulate and gaseous pollutant from waste gas ● CO4: To analyse the techniques used for treatment of industrial wastes and case studies						
Topics Covered	**Module I:** Introduction and Physico-chemical Treatment Introduction to environment, Constituents of environment, Sources of water and its						

	uses: domestic and industrial. Domains of environmental degradation and its root causes, Characteristics of drinking and wastewaters, WHO standards, Physical, chemical and biological treatment techniques, Treatment options and selection of appropriate treatment scheme. Physico-chemical treatment units, Screening, Grit Chamber, Mixing, Principles of settling, Coagulation, Flocculation, Design and operation of settling tanks, Chemical treaments, Advanced oxidation, WET oxidation, Catalytic degradation, Membrane based separation, Ion exchange and disinfection of water, Adsorption, etc. [10 hrs] **Module II:** Biological Treatment Process design and operation of attached growth, suspended growth, hybrid/integrated process, Design and operation of biological treatment units like ACS, Biofilter, Trickling Filter, RDC, Design and operations of lagoons, and troubleshooting of ACS units, Phycoremediation; Toxicity analysis of untreated and treated wastewater for its further use. [10 hrs] **Module III:** Air Pollution Air pollution- sources, classification, health hazards, Dispersion of air pollutants, plume behaviour, Stack design, abatement techniques of air pollutants, Design and operation of control devices, Design and operational problems of gravity separators, cyclone separators, ESP, Filtration, Bag Filter – Operation and Principle, Water scrubbing, venture scrubber Abatement of gaseous pollutants like SO_x, NO_x, CO_2 etc., Powers and functions of state and central PCBs, GHG emission, global warming, climate change. [10 hrs] **Module IV:** Industrial wastes and Case Studies Industrial wastes and their sources: Various industrial processes, Sources and types of solid, liquid, gaseous wastes, Solid waste management, Noise & radiation emissions. Processes responsible for deterioration of environment, Various waste water streams, Control and removal of specific pollutants in industrial wastewaters, e.g., oil and grease, bio-degradable organics, chemicals such as cyanide, fluoride, toxic organics, heavy metals, radioactivity etc. Wastewater reuse & recycling, Modern trend in load reduction. Effluent treatment plant design, Concept of zero discharge effluent. Recent trends in industrial waste management, Cradle to grave concept, Life cycle analysis, Clean technologies, Case studies of various industries, e.g., dairy, fertilizer, distillery, sugar, pulp and paper, iron and steel, metal plating, thermal power plants, etc. Concept of waste utilization and value added product recovery and its impact in society. [12 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Wastewater Engineering-Treatment and Reuse. Metcalf & Eddy, 4th Edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/MathISBN-13: 978-0070418783, ISBN-10: 0070418780.

	2. Environmental Engineering, M. L. Davis and D. A. Cornwell; 3rd Edition (January 1, 1998), Publisher: WCB/McGraw-Hill; ISBN 10: 0070159114ISBN 13: 9780070159112. Suggested Reference Books: 1. Fundamentals of Water Treatment Unit Processes: Physical, Chemical, and Biological. David Hendricks. Publisher: CRC Press/ IWA Publishing, 2011; ISBN-10: 1420061917, ISBN-13: 978-1420061918. 2. Environmental Engineering. Howard Peavy, Donald Rowe, George Tchobanoglous Publisher: McGraw Hill Education (India) Private Limited; First edition (1 August 2013); ISBN-10: 9351340260, ISBN-13: 978-9351340263. 3. Environmental Pollution Control Engineering. C.S. Rao; 2nd Edition, Publisher: New Age International, 2006; ISBN-13:9788122418354, ISBN-10:812241835X. 4. Air Pollution Control Equipment. H. Brauer and Y. B. G. Verma; Latest Edition; Publisher: Springer, 1981; ISBN-13:9783540104636, ISBN-10:3540104631. 5. Environmental Engineering. Arcadio P. Sincero and Gregoria A. Sincero; 1st Edition (August 18, 1995), Publisher: Prentice Hall; ISBN-13: 978-0024105646, ISBN 10: 0024105643. 6. Edmund, B. Besselieve P.E. "The Treatment of Industrial Wastes", Mc-Graw Hill. 7. Nancy, J.S. "Industrial Pollution Control: Issues and Techniques", Van Nostrand Reinhold. 8. Shen, T.T. "Industrial Pollution Prevention Handbook", Springer-Verlag. Environment (protection) Act - 1986, Ministry of Environment and Forest, Government of India.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	2	-	-
CO2	3	2	-
CO3	3	2	-
CO4	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9014	**NON-CONVENTIONAL ENERGY ENGINEERING**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Fundamental of fuels, Mathematics	CT+EA

Course Outcomes	• CO1: Learn about energy technology of different conventional and nonconventional energy resource and Recent worldwide energy market scenario. • CO2: Design & analyze of different renewable energy collectors and renewable energy thermal power plants. • CO3: Learn industrial and domestic applications of different renewable energy sources. • CO4: Solve energy technology problems of different difficulty levels through tutorials
Topics Covered	**Module I:** Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts, Distributed generation. [4 hrs] **Module II** Solar Energy: Solar radiation and its measurement, limitations in the applications of Solar Energy, Solar collectors – types, and constructional details. Solar water heating, applications of Solar Energy for heating, drying, space cooling, water desalination, solar concentrators, photovoltaic power generation using silicon cells. solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, energy plantations, Photo voltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing and economics. Peak power operation. Standalone and grid interactive systems. [10 hrs] **Module III** Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating. Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation. Small Hydro Systems. [10 hrs] **Module IV** Nuclear Energy: Nuclear fission principles, types of nuclear reactors (BWR, PWR, PHWR, LMCR, GCR, FFR). Nuclear reactor analysis: four factor formula, resonance absorption, reactor buckling, multiplication factor, thermal utilisation coefficient, reflector saving, fast fission factor, optimum moderator to fuel ratio. Radioactive waste disposal. [10 hrs] **Module V** Geothermal Energy: Geo technical wells and other resources dry rock and hot aquifer analysis, harnessing geothermal energy resources. Ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion. Biomass and Biofuels: Recycling of agricultural waste, anaerobic/aerobic digestion, and types of biogas digesters, gas yield, and combustion characteristics of bio gas,

	design of biogas system for heating. Biofuels such as biodiesel, ethanol, bio-butanol etc. and their production and present status. [10 hrs] **Module VI** Energy Storage and Distribution: Importance, biochemical, chemical, thermal, electric storage. Fuel cells, distribution of energy. Energy Storage -Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. [10 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable,World, John Wiley. 2. Bansal N.K., Kleeman M. & Meliss M., Renewable Energy Sources & Conversion Tech., Tata McGraw Hill. 3. Sukhatme S.P., Solar Energy, Tata McGraw Hill 4. Mittal K.M., Non-Conventional Energy Systems, Wheeler Pub. 5. Pandey G.N., A Text Book on Energy System and Engineering, Vikas Pub. 6. Rai G.D., Non-Conventional Energy Sources, Khanna Pub. Suggested Reference Books: 1. Venkataswarlu D., Chemical Technology, I, S. Chand 2. Rao S. & Parulekar B.B., Energy Technology, Khanna Pub.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	1	2	1
CO2	2	2	2
CO3	3	2	3
CO4	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9015	**CHEMICAL PROCESS OPTIMIZATION**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Mathematics, Chemical Engineering Computing Laboratory		CT+EA					

Course Outcomes	• CO1: Able to apply the knowledge of optimization and optimum design and an overview of optimization methods. • CO2: Ability to solve various multivariable optimization problems and solve chemical process optimization issues using MATLAB. • CO3: Develop skills to implement the theory and applications of optimization techniques in a comprehensive manner for solving linear and non-linear, geometric, dynamic, integer and stochastic programming techniques. • CO4: Identify, formulate and solve a practical engineering problem of their interest by applying or modifying an optimization technique.
Topics Covered	**Module I:** The nature and organization of optimization problems, scope and hierarchy of optimization, examples of applications of optimization in chemical industry, essential features of optimization, general procedures for solving optimization problems, basic concepts of optimization, continuity of functions, unimodal vs multimodal functions, convex and concave functions, convex region, necessary and sufficient conditions for an extremum of an unconstrained function, interpretation of the objective function in terms of its quadratic approximation. [5 hrs] **Module II:** Optimization of unconstrained function, one dimensional search, numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton, Quasi, Newton and Secant methods of uni, dimensional search, region elimination methods, polynomial approximation methods, one dimensional search applied in a multidimensional problem, evaluation of uni-dimensional search methods, unconstrained multivariable optimization , direct methods, indirect methods–1 st order, 2 nd order; secant methods. [10 hrs] **Module III:** Linear programming and applications, basic concepts in linear programming, degenerate LPs–graphical solution, natural occurrence of linear constraints, simplex method of solving linear programming problems, standard LP form, obtaining a first feasible solution, revised simplex method, LP applications in chemical industry. [7 hrs] **Module IV:** Linear Regression, Multiple, polynomial and general least square regression, Nonlinear regression; Regression: MATLAB implementation. [5 hrs] **Module V:** Teaching-Learning based optimization(TLBO), Implementation of TLBO in MATLAB, Particle Swam Optimization (PSO), Implementation of PSO in MATLAB, Differential Evolution(DE), Implementation of DE in MATLAB, Genetic Algorithm(GA), Implementation of GA in MATLAB, Other MATLAB optimization tools and in-built functions. [15 hrs]
Text Books, and/or reference	Suggested Text Books: 1. Edgar, T.F. and Himmelblau, D.M., Optimization of Chemical Processes, McGraw Hill, 1989. 2. Deb K., Optimization for engineeringdesign, Algorithms and examples,

material	PrenticeHallofIndia, New Delhi, 2005. 3. Urbanier, K. and McDermott, C., Optimal Design of Process Equipment John Wiley, 1986. Suggested Reference Books: 4. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M., Engineering Optimization, John Wiley, New York, 1980. 5. Biles, W.E. and Swain, J.J., Optimization and Industrial Experimentation, Inter Science, New York, 1980. 6. Seinfield, J.H., Lapidus, L., Process Modelling, Estimation and Identification, Prentice Hall, Englewood Cliffs, new Jersey, 1974.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	1
CO3	3	1	2
CO4	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9016	**MULTIPHASE FLOW**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fluid mechanics, heat transfer, transport phenomena, mathematical methods		CT+EA					
Course Outcomes	● CO1: To learn the fundamental concepts and applications of multiphase flow ● CO2: To learn the numerical models and methods for transport mechanisms and design strategy for multiphase flow ● CO3: To learn the dynamics of bubble, drop and solid particle ● CO4: To learn the measurement methods for multiphase flow						
Topics Covered	**Module I:** Fundamental concepts and applications of multiphase flow Two-phase flow; three-phase flow; components; fields; space and time-averaging; volume/void fraction; flow quality; superficial velocities; phase velocities; volumetric flux; velocity ratio; slip; volume and mass-centered velocity; homogeneous flow; drift flux;						

	separated flow; Martinelli parameters; two-phase multiplier and correlations; two-phase pressure drop; isothermal and non-isothermal flows; applications of nuclear, thermal, petroleum, chemical industries and in nature. [6 hrs] **Module II:** Flow patterns and transitions Flow patterns; identification and classification; flow pattern maps and transition in gas-liquid, solid-gas, solid-liquid, gas-solid-liquid flows; boiling channel; bubble column, fluid bed; trickle beds; prediction of holdup and pressure drop in different flow regimes.[6 hrs] **Module III:** Numerical models and methods Conservation equations for mass, momentum and energy for heat transfer and flow field in multiphase flow; homogeneous and separated flow model; drift flux model; two-fluid models; Eulerian and Lagrangian methods; numerical methods for solutions; closure equations for fluid-wall and interfacial transports of heat and momentum; drift flux and slip correlations for bubbly, slug, annular and stratified flows. [12 hrs] **Module IV:** Dynamics of bubble, drop and solid particle Growth of bubble and drop; terminal velocity of bubble, drop and particle; pinch-off; contact line and triple contact lines; coalescence; breakup and collapse; deformation of bubbles and particles; flow around a spherical particle; flow through porous medium. [8 hrs] **Module V:** Measurement methods in multiphase flow: Two-phase pressure drop, void fraction, phase indication; phase distributions; phase velocities; anemometry; velocimetry; densitometry; optical methods; electrical methods. [10 hrs]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Yadigraoglu, G., Hewitt, G. F., Introduction to Multiphase flow – Basic Concepts, Applications and Modeling. Springer, 2018. 2. Wallis, G. B., “One Dimensional Two Phase Flow”, McGraw Hill Book Co., 1969. 3. Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 3rd ed., Oxford University Press 4. Ghiaasiaan, S. M., Two-Phase flow, Boiling, and Condensation, Cambridge University Press, 2007. 5. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998. 6. Govier, G. W. and Aziz. K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold, New York, 1972. 7. Prosperetti, A., Tryggvason, G., Computational Methods for Multiphase Flow, Cambridge University Press, 2007 <u>Suggested Reference Books:</u> 1. G. Hetsroni, Handbook of Multiphase Systems, Mcgraw-Hill Book Company, 1982.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	3	3	3

CO2	3	3	3
CO3	3	3	2
CO4	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9018	**PETROLEUM REFINING AND PETROCHEMICAL ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fuel and combustion		CT+EA					
Course Outcomes	• CO1: Understanding the role of petroleum as energy source amidst world energy scenario • CO2: Learning design and operation of petro refineries and petrochemical complexes • CO3: Learning safe practices in operations of refineries and petrochemical complexes • CO4: Identifying challenges, energy security issues and environmental issues						
Topics Covered	**Module I:** Petroleum - Origin and Occurrence, Exploration, Estimation and recovery, Evaluation of crude, Properties, testing and specifications of petroleum products, Problems & Prospectus of petroleum refining in India. [10 hrs] **Module II:** Processing of Crude Petroleum - Atmospheric and Vacuum distillation, column control schemes, Conventional thermal cracking – vis-breaking and design variables of vis-breaking – coking: Fluid coking, flexi coking, delayed coking and hardware considerations – catalytic conversion processes -fluid catalytic cracking with special reference to catalyst and reactor design configurations – hydro-treating, hydrodesulphurization and hydro-cracking – Reforming: process, catalyst, reactor design configuration – alkylation – isomerization – lube oil manufacturing process, solvent – de-asphalting, solvent de-waxing. [12 hrs] **Module III:** Production of finished petroleum goods like, LPG, Kerosene, Petrol, Diesel, Lubricating Oil, Bitumen, environmental norms of products. [4 hrs] **Module IV:** Petrochemical technology: Petrochemical industry overview, primary raw materials for petrochemicals, first generation petrochemicals – hydrocarbon intermediates and their production, non-hydrocarbon intermediates, olefin production, processing of olefins from steam cracking and fluid cracking.						

	[6 hrs] **Module V:** Aromatics production– benzene, toluene and xylene derivatives – Properties, applications and production technologies, third generation petrochemicals – polymers, elastomers, polyurethanes and synthetic fiber. [10 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Ram Prasad, "Petroleum Refining Technology", Khanna Publishers, Delhi, 2000 2. J. H. Gary, G. H. Handwerk and M. J. Kaiser, "Petroleum Refining Technology and Economics", 5th Edition, CRC Press, New York, 2007 3. G. D. Hobson and W. Pohl, "Modern Petroleum Technology", 6th Edition, Wiley, New York, 2000. 4. Nelson, W.L "Petroleum Refinery Engineering" McGraw Hill Publishing Company Limited, 1985. 5. B. K. Bhaskara Rao, "A Text on Petrochemicals", Khanna Publishers, New Delhi, 2008. Suggested Reference Books: 1. R. A. Meyers, "Handbook of Petroleum Refining Processes", 2nd Edition, McGraw Hill, New York, 1996 2. J. A. Moulijin, M. Makkee and A. Van Diepen, "Chemical Process Technology", Wiley, New York, 2001. 3. I. D. Mall, "Petrochemical Process Technology", Macmillan India Ltd, New Delhi, 2007. 4. Sami Matar and Lewis F Hatch, "Chemistry of Petrochemical Processes", Gulf Publishing Company, Houston, Texas, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	2	2	2
CO2	3	2	3
CO3	3	2	3
CO4	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CH 9020	**MATHEMATICAL HEAT TRANSFER AND**	PEL	3	0	0	3	3

	FLUID FLOW						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Heat transfer, fluid mechanics, transport phenomena, mathematical methods		CT+EA					
Course Outcomes	● CO1: To learn the mathematical models and methods for the design strategy for heat transfer equipment applications of nuclear, aerospace, thermal, metal, petroleum, chemical industries. ● CO2: To learn how to derive analytically the variation of local Nusselt number, temperature and velocity fields to validate the numerical solutions.						
Topics Covered	**Module I:** Introduction to mathematical methods Method of separation variables; method of combination variables; solutions of ODEs and PDEs (1-D and 2-D) using gamma functions, beta functions, error functions, Bessel's functions, green functions, power series, Fourier series, Fourier-Legendre series, integral transform, Fourier transform, Laplace transform Finite difference method, adaptive finite difference method; volume of fluid; finite element method [10 hrs] **Module II:** Heat transfer in laminar flow Equations of energy, motion and continuity; differential and integral equation of momentum and thermal boundary layers; boundary layer approximation, initial and boundary conditions; exact solution of boundary layer equations; Steady-state laminar flow over a semi-infinite flat plate – analytical solution of Navier-Stokes equation and Blasius equation, Laminar boundary heat transfer from a semi-infinite plate at a constant temperature; Heat transfer in high velocity thermal boundary layer Heat transfer in laminar flow through pipe; constant heat flux and constant wall temperature; fully developed flow and entrance length; Exact solution of Sturm-Liouville systems, computation of Eigen functions and Eigen values; Bessel's functions and zeros; orthogonal Eigen functions. Natural convection on a vertical flat plate [10 hrs] **Module III:** Heat transfer in spherical geometry Stokes flow past sphere; potential flow; stream functions; steam lines; velocity vector fields; dynamics of vortex motion Heat transfer to heat transfer from a solid sphere in stagnant liquid; steady-state Solution of heat transfer to a moving sphere a constant diameter in stagnant liquid; Similarity solutions for a transient heat conduction problem; similarity solutions of the boundary layer equations for natural convection over spherical surface. Exact solution of heat transfer and flow field during the growth and departure of a vapor-bubble; evaporation from drops [8 hrs]						

	Module IV: Heat transfer in turbulent flow Reynolds averaged Navier-Stokes equation (RANS); Prandtl's mixing-length hypothesis; universal velocity profile; Reynolds averaged form of energy equation; turbulent heat transfer in pipe; k-ε model of turbulence; conjugate heat transfer problems. [6 hrs] **Module V:** Numerical solutions Navier-Stokes equation; Blasius equation; Sturm-Liouville systems; heat transfer and flow field in single-phase and two-phase flow with phase change. [8 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. W.M. Kays, Convective heat and mass transfer, First, McGraw Hill Book Company, New York, 1966. 2. W. J. Minkowycz, E. M. Sparrow, G. E. Schneider, R. H. Pletcher, Handbook of Numerical Heat Transfer, Wiley Interscience, New York, 1988 3. H. Schlichting, Boundary layer theory,; McGraw Hill Education; 7th edition, New York, 2014 4. G. Biswas, A. Dalal, V. K. Dhir, Fundamentals of Convective Heat Transfer, CRC Press-Taylor and Francis, India, 2019. 5. B. Weigand, Analytical Methods for Heat Transfer and Fluid Flow Problems, Springer, 2015. Suggested Reference Books: 1. L. Prandtl, O.G. Tietjens, L. Rosenhea (Translator) Fundamentals of Hydro- and Aeromechanics, Dover Publications Inc,New York, 1934. 2. R. B. Bird, W. E. Stewart, E. N. Lightfoot, Transport phenomena, 1st ed., John Wiley & Sons, New York, 1960.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9021	**ETHICS IN**	PEL	3	0	0	3	3

	ENGINEERING PROFESSION						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
--		CT+EA					
Course Outcomes	• CO1: To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity, which are the core aspirations of all human beings • CO2: To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of Existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way. • CO3: To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature						
Topics Covered	**Module I:** Course Introduction - Need, Basic Guidelines, Content and Process for Value Education Understanding the need, basic guidelines, content and process for Value Education. Self-Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facilities- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario Method to fulfil the above human aspirations: understanding and living in harmonyat various levels. [10 hrs] **Module II:** Understanding Harmony in the Human Being - Harmony in Myself! Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - *Sukh* and *Suvidha* Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) Understanding the characteristics and activities of 'I' and harmony in 'I' Understanding the harmony of I with the Body: *Sanyam* and *Swasthya*; correct appraisal of Physical needs, meaning of Prosperity in detail Programs to ensure *Sanyam* and *Swasthya* - Practice Exercises and Case Studies will be taken up in Practice Sessions. [10 hrs] **Module III:** Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship *Understanding Harmony in the family – the basic unit of human interaction* Understanding values in human-human relationship; meaning of *Nyaya* and program for its fulfillment to ensure *Ubhay-tripti*; Trust (*Vishwas)* and Respect (*Samman)* as the foundational values of relationship						

	Understanding the competence meaning of *Vishwas*; Difference between intention and competence Understanding the meaning of *Samman*, Difference between respect and differentiation; the other salient values in relationship Understanding the harmony in the society (society being an extension of family): *Samadhan, Samridhi, Abhay, Sah-astitva* as comprehensive Human Goals Visualizing a universal harmonious order in society- Undivided Society (*Akhand Samaj),* Universal Order (*Sarvabhaum Vyawastha)*- from family to world family! - Practice Exercises and Case Studies will be taken up in Practice Sessions. [11 hrs] **Module IV:** Implications of the above Holistic Understanding of Harmony on Professional Ethics Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order Competence in professional ethics: a) Ability to utilize the professional competence for augmenting universal human order b) Ability to identify the scope and characteristics of people-friendly and ecofriendly production systems, c) Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems Strategy for transition from the present state to Universal Human Order: a) At the level of individual: as socially and ecologically responsible engineers, technologists and managers b) b) At the level of society: as mutually enriching institutions and organizations [11 hrs]
Text Books, and/or reference material	<u>Suggested Text Books:</u> **1.** R.R Gaur, R Sangal, G P Bagaria, A foundation course in Human Values and professional Ethics, Excel books, New Delhi, 2010, ISBN 978-8-174-46781-2. <u>Suggested Reference Books:</u> 1. B L Bajpai, 2004, *Indian Ethos and Modern Management*, New Royal Book Co., Lucknow. Reprinted 2008. 2. PL Dhar, RR Gaur, 1990, *Science and Humanism*, Commonwealth Purblishers. 3. Sussan George, 1976, *How the Other Half Dies,* Penguin Press. Reprinted 1986, 1991 4. Ivan Illich, 1974, *Energy & Equity,* The Trinity Press, Worcester, and HarperCollins, USA 5. A.N. Tripathy, 2003, *Human Values*, New Age International Publishers. 6. Primary resource material will be provided by the course instructor

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	1

CO3	3	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9023	**CFD APPLICATIONS IN CHEMICAL ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basics of Fluid Mechanics, Transport Phenomena, Numerical Methods		CT+EA					

Course Outcomes	● CO1: To learn basics of continuum based modelling and simulations; its area of applications and limitations. ● CO2: To learn different discretization methods of continuum based governing equations. ● CO3: To learn different steps of CFD simulations. ● CO4: To learn the use of CFD techniques in realistic problems.
Topics Covered	**Module I:** Introduction: Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modelling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools. [5 hrs] **Module II:** Principles of Solution of the Governing Equations: Finite difference, Finite volume and Finite Element Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation. [8 hrs] **Module III:** Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation. [4 hrs] **Module IV:** Solution Algorithms: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.

	[15 hrs] **Module V:** CFD Solution Procedure: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. [5 hrs] **Module VI:** Case Studies: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem. [5 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Numerical heat transfer and fluid flow by S.V. Patankar, Hemisphere Publishing Corporation, 1980. 2.Introduction to Computational Fluid Dynamics by Anil W. Date, Cambridge University Press, 1st Edition, 2005. 3. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill (1998). Suggested Reference Books: **1.** Muralidhar, K.,and Sundararajan, T. Computational Fluid Flow and Heat Transfer, Narosa Publishing. House (1995). **2.** Computational Fluid Dynamics and Heat Transfer by P S Ghosdastidar (Publisher: Cengage Learning India) **3.** Ranade, V.V., Computational flow modeling for chemical reactor engineering, Academic Press (2002).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	3	2
CO2	3	2	2
CO3	3	3	3
CO4	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9026	**NANOTECHNOLOGY**	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Basic knowledge of Chemistry, Physics and Mathematics		CE+EA
Course Outcomes	• CO1: Acquire the concept of nanoscience and nanotechnology at the basic level to apply for different application. • CO2: Acquire the concept of synthesis and characterization of nanomaterials. • CO3: Acquire the idea how to apply nanotechnology in different fields (catalysis, energy and environment) for better efficiency.	
Topics Covered	**Module I:** Introduction, History of Nanomaterials synthesis approach of nanomaterials, various kind of nanostructures. [10 hrs] **Module II:** Synthesis of nanomaterials: Physical Methods, Chemical Methods and Biological Methods. Properties of Nanomaterials: Mechanical, Structural, Thermal, Electrical and Optical properties. [11 hrs] **Module III:** Characterization techniques of nanomaterials: Spectroscopy, XRD, BET, TGA, SEM, TEM and XPS. [11 hrs] **Module IV:** Application of the nanomaterials in different fields. Nanolithography, Nanocomposites. Nanoparticles as catalyst Nanoparticles in energy and environment application. Nanoparticles in biomedical application. [10 hrs]	
Text Books, and/or reference material	Suggested Text Books: **1.** Dieter Vollath, Nanomaterials: An introduction to synthesis, properties and application, Wiley-VCH Verlag GmbH & Co. Weinheim, Germany, 2008. **2.** CNR Rao, PJ Thomas, GU Kulkarni, Nanocrystals: Synthesis, Properties and Applications, Springer-Verlag Berlin Heidelberg 2007. **3.** T. Pradeep, Nano: The Essentials, Understanding Nanoscience and Nano Technology, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007. Suggested Reference Books: 1. Goddard III, WA, Brenner, DW, Lyshevski, SE, Iafrate, GJ. Handbook of nanoscience, Engineering and Technology, 2^{nd} Edition, CRC Press. 2. Nanotechnology: Principles & Practices; Sulabh K. Kulkarni, Capital Publishing Company, Kolkata 3. In some cases research articles.	

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	2	2	3

CO2	3	-	3
CO3	3	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH 9027	**COMPUTER AIDED PROCESS ENGINEERING**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
--		CT+EA					
Course Outcomes	● CO1: Learnaboutfundamentals of Mathematical modelling, simulations, process design and learn to develop modellingof different unit operations ● CO2: Design&analyzeofdifferentof processes equipment ● CO3: Learn theanalysisand solvingmethods of mathematical modelled equation and completeprocess model of chemical unit operations throughassignment /grouptask						
Topics Covered	**Module I:** Overview of Process engineering, modelling, Simulation and Design Fundamental of process engineering, Concept of Mathematical model, simulation and process analysis. Scopes and uses of simulation in process engineering. Fundamentals of model building. Classification uses of mathematical models. Formulation of mathematical models. Reviews of continuity equation - energy equation-momentum equation-equation of state- equilibrium-kinetics, Difference between Process modelling, simulation and Process design, Phenomenological modelling, data driven black box modelling, Grey box modelling [8 hrs] **Module II:** Introduction to process simulators Use of simulation, basis of Flow sheet simulation, Advantage of simulation, Understanding the simulation problem, Approaches to flowsheet simulation, Sequential modular and equation oriented, Structure of a process simulator, features of commercial simulators, Flow sheet tropology level, Unit operation models and physical property models, Steps in Aspen simulation. Run the first Aspen Simulation., Physical property environment, Use of method assistant to know the physical property method, Workshop on property analysis in Aspen.[8 hrs] **Module III:** Process engineering calculations related toFluid Mechanics Process engineering calculations related to Friction Factor, Flow of Fluids in Pipes, Friction Loss, Overall Pressure Drop, Flow through Tank, Compressible Fluid Flow in						

	Pipes, Two-Phase Flow in Pipes, Flow through Packed Beds, use of Aspen simulators to design and simulations of Pumps and compressors, pressure drop in pipeline [8 hrs] **Module IV:** Design and simulations of Distillation columns Process engineering calculations related to Diffusion, Unsteady-State Mass Transfer, Multiple-Effect Evaporators, Design and simulations of distillation columns in commercial simulators: Short cut Distillation design, Short cut Distillation rating, Rigorous Binary and multicomponent Distillation design and rating, Hydraulic calculations of distillation towers, Complete Plant/manufacturing set up design, Solvent recovery plants. [8 hrs] **Module V:** Design and simulations of Heat exchanger Overview of Heat exchanger modules available in Aspen, Heat exchanger simulations by simplified model in commercial simulators, Rigorous heat exchanger design by EDR module. [8 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Applied Mathematics inChemical Engineering:MickleyTMH 2. Mathematical Methods in Chemical Engineering:S. Pushpavanam, PHI 3. Numerical methods forMathematics, Science and Engineering: John H. Mathews, PHI Suggested Reference Books: 1. Applied Numerical Methods: Alkis Constantinides, McGrawHill 2. Luyben,et al., Process modelingsimulation and Control, McGrawHill 3.Henleyand Seader, Multistageseparation, McGraw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	2	2	1
CO2	3	3	2
CO3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9028	**ADVANCED WATER AND WASTEWATER TECHNOLOGY**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA
Course Outcomes	• CO1: To learn the objective, operational principles and different treatment technologies' barriers and to empower personnel with skills required to handle effluent treatment design, analysis and selection. • CO2: To master key unit processes for assessment and the use of relevant methods for advanced water treatment, and to apply these to specific needs. • CO3: To enhance ability to diagnose and improve existing wastewater technologies and familiarize with the advanced developments in effluent treatment technology.
Topics Covered	**Module I:** Introduction, Introduction to the Issues of Access to Safe Drinking Water, Worldwide Temporal and Spatial Variation of Water Resources, Water-Quality Standards and Sources and Classification of Pollutants, Introduction to Water Resource Management Approaches [5 hrs] **Module II:** Physicochemical and Chemical Treatment Technology Introduction, Coagulation–Flocculation–Precipitation–Filtration, Physicochemical Treatment Technology Based on Coagulation–Flocculation–Settling, Adsorption Principles, Adsorption-Based Technology Aeration, Chemical Neutralization, Chemical Oxidation, Chemical Precipitation, Ion Exchange, Disinfection of Water, Advanced Oxidation Technology [8 hrs] **Module III:** Water Treatment by Membrane-Separation Technology Introduction, Classification of Membrane-Based Processes, Membrane-Separation Terminology, Flow Modes, Membrane Materials, Membrane Modules, Transport Mechanisms in the Membrane-Separation Process, Transport Modeling in Nanofiltration, Selection of Membrane Technology in Water Treatment, Microfiltration Technology in Water Treatment, Ultrafiltration Technology in Water Treatment, Nanofiltration Technology in Water Treatment, Pervaporation Technology in Water Treatment, Reverse Osmosis Technology in Water Treatment, Forward Osmosis Technology in Water Treatment, Integrated Membrane Technology in Groundwater and Wastewater Treatment, Forward Osmosis Technology In Power Generation, Membrane Distillation Technology in Water Treatment [10 hrs] **Module IV:** Biological Treatment Technology Introduction to Biological Treatment Technologies, Wastewater Biodegradability: Selection of Treatment Technology, Microbial Growth Kinetics: Unstructured model, Bioreactor Configurations of Biological Treatment Technologies, Biological Treatment Using Fluidized-Bed Reactor Technology, Conventional Biological Treatment Technologies, Advances in Biological Treatment Technologies, Case Studies. [7 hrs] **Module V:**

	Industry-Specific Water Treatment: Case Studies [5 hrs] **Module VI:** Nanotechnology in Water Treatment Introduction, Nanomaterials as Adsorbent in Water Treatment, Nanomaterials in Water Purification as Membrane, Nanomaterials in Photocatalytic Degradation of Water Pollutants, Nanomaterials in Disinfection of Contaminated Water. [7 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Wastewater Treatment, Disposal, Reuse, Eddy and Metcalf 2. Parimal Pal, "Industrial Water Treatment Process Technology" 1st Edition, 2017, Elsevier. Reference Book: 1. Handbook of Water and Wastewater Treatment Technologies, AuthorsNicholas P. Cheremisinoff, ISBN 978-0-7506-7498-0, Copyright © 2002 Elsevier Inc. All rights reserved 2. All latest Journals (National & International)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	3	1	3
CO2	3	2	3
CO3	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9030	**COLLOIDS AND INTERFACE ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic Chemistry, Physics and Mathematics		CT+EA					
Course Outcomes	• CO1: Acquire an idea about the application of colloidal chemistry, fluid-fluid and solid-fluid interface engineering in different industrial fields. • CO2: To learn the fundamental knowledge of intermolecular forces involved in colloids and interfaces						

	• CO3: Introduction to surface active agent and learn about the application of surface active agents to enhance the efficiency in the process.
Topics Covered	**Module I:** Importance and scope of the subject. Overview of colloidal systems, interfaces and surface. Properties and application of the colloids. Colloidal stability factor. Kinetic theory of colloidal systems: sedimentation, centrifugation, diffusion, Domestic and industrial application of colloidal solution. Adsorption at fluid-fluid and fluid-solid interface, Thermodynamics of interfaces, Interfacial rheology and transport process. [10 hrs] **Module II:** Surface active agent: Surfactant, Surface and interfacial tension, surface free energy. Surface tension for curved interfaces, Surface excess and Gibbs equation. Theory of surface tension, contact angle, and wetting. Thermodynamics of micelle and mixed micellar formation. Adsorption of single and mixed surfactants at interfaces, Mixed micellar properties, Rheology of surfactant systems. Preparation, mechanistic details of stabilization and relationship between HLB and solubility parameter, characterization and Application [10 hrs] **Module III:** Intermolecular forces relevant to colloidal systems: Electrostatic and van der Waals forces. DLVO theory. Measurement techniques of surface tension, contact angle, zeta potential, particle size. [10 hrs] **Module IV:** Overview of industrial applications of various interfacial phenomena in the industries [Mattress industry (Foam: preparation, characterization, stability), petroleum industry, Mineral processing industry Pesticides, firefighting, personal care formulations] Super hydrophobic surface and self-cleaning surfaces. Case studies related interfacial science. Introduction to Nanotechnology. Application of interfacial engineering concept through the surface modification for the synthesis of nanostructured material by using surface active agent. [12 hrs]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. P. C. Hiemenz, and R. Rajagopalan, Principle of colloid and surface chemistry, 3rd edition, Mercel Dekher, N. Y. 1997. 2. Pallab Ghosh, Colloid and Interface Science, 1st Edition, PHI Learning, 2009. 3. M. J. Rosen, Surfactants and Interfacial Phenomena, Wiley-Interscience Publication, New York, 2004. <u>Suggested Reference Books:</u> 1. Drew Myers, Surfaces, Interfaces and Colloids, 3rd Edition, Wiley, 2006. 2. Tharwat F. Tadros, Applied Surfactants Principles and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2005.

	3. Israelachvili, Intermolecular and Surface Forces, Academic Press, New York, 1992.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	2	1
CO2	3	-	-
CO3	3	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH9034	**PINCH TECHNOLOGY IN PROCESS INDUSTRY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Heat Transfer		CT+EA					

Course Outcomes	• CO1: Acquire an idea to optimize the process heat recovery and reducing the external utility loads. • CO2: To achieve financial saving by constructing the best process heat integration.
Topics Covered	**Module I:** Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram. Overview of Pinch Technology: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology. Key steps of Pinch Technology: Concept of ΔT_{min}, Data Extraction, Targeting, Designing, Optimization-Supertargeting Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve. Targeting of Heat Exchanger Network: Energy Targeting, Area Targeting, Number of units targeting, Shell Targeting and Cost targeting. [12 hrs] **Module II:** Designing of HEN: Pinch Design Methods, Heuristic rules, stream splitting, and design of maximum energy recovery (MER). Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems

	and design strategy.Network evolution and evaluation-identification of loops and paths, loop breaking and path relaxation. [12 hrs] **Module III:** Design tools to achieve targets, Driving force plot, remaining problem analysis, diverse pinch concepts, MCp ratio heuristics. Targeting and designing of HENs with different ΔT_{min} values, Variation of cost of utility, fixed cost, TAC, number of shells and total area with ΔT_{min} Capital-Energy trade-offs. Process modifications-Plus/Minus principles, Heat Engines and appropriate placement of heat engines relative to pinch. Heat pumps, Appropriate placement of heat pumps relative to pinch. Steam Rankin Cycle design, Gas turbine cycle design, Integration of Steam and Gas turbine with process. Refrigeration systems, Stand alone and integrated evaporators. Heat integrations and proper placement of Reactors for batch Processes as well as continuous processes. [12 hrs] **Module IV:** Case studies on heat integration by pinch technology [6 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Ian C. Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, 2nd Edition, ISBN: 9780750682602, Butterworth-Heinemann, 2016. 2. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. of Chemical Engineers. Suggested Reference Books: 1. Shenoy U. V.; "Heat Exchanger Network Synthesis", Gulf Publishing Co. 2. Smith R.; "Chemical Process Design", McGraw-Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	1	2	2
CO2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit (C)
			Lecture (L)	Tutorial (T)	Practical (S)	Total Hours (H)	
CH 9042	**MEMBRANE**	PCR	3	0	0	3	3

	TECHNOLOGY IN ENVIRONMENTAL POLLUTION CONTROL						
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
--		CT+EA					
Course Outcomes	• CO1: Understanding fundamentals of membrane separation and membrane-based technologies • CO2: Understanding synthesis of membranes and operations of membrane modules for membrane-based technology development • CO3: Understanding application of Membrane Technology in separation-purification and green production in innovative way • CO4: Ignited Minds with passion for developing novel technologies in solving environmental problems						
Topics Covered	**Module I:** Membrane materials, membrane-based processes and membrane modules. [6 hrs] **Module II:** Introduction to membrane-based technology, application potentials of micro, ultra, nano, reverse osmosis, forward osmosis and other integrated membrane processes in water treatment, bio separation, biofuel production, air pollution control, green chemical production. [5 hrs] **Module III:** Introduction to modelling membrane separation, modelling microfiltration, ultrafiltration, nanofiltration, reverse osmosis, forward osmosis, membrane distillation and integrated processes. [6 hrs] **Module IV:** Introduction to Membrane-based technologies in air pollution control. Membrane technology in controlling particulates, and gaseous pollutants (SO_x, NO_x, CO_2, CO). [5 hrs] **Module V:** Membrane-based technologies in groundwater treatment, surface water treatment, industrial wastewater treatment, turning waste to wealth through membrane technology, closed loop wastewater treatment using multistage membrane separation. [10 hrs] **Module VI:** Introduction to development of green technology using membranes, green chlor-alkali production, green biofuel production, green biochemical production. Process intensification through membrane technology, analysis of space intensification, energy reduction, eco-friendly production through adoption of membrane technology. [10 hrs]						

Text Books, and/or reference material	Suggested Text Books: 1. Membrane-based Technologies for Environmental Pollution control, Parimal Pal, Elsevier Sci. Suggested Reference Books: 1. Industrial Water Treatment Process Technology, Parimal Pal, Elsevier 2. Groundwater Arsenic Remediation: Treatment Technology & Scale Up, Parimal Pal, Elsevier Sci.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	2
CO3	2	3	3
CO4	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CH 9043	**BIOFUEL TECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Students know details biofuel production, they can calculate energy balance of biofuel production students know principles and thermodynamics of gasification processes • CO2: students know advanced power plants concepts (IGCC, chemical looping) • CO3: students know details of gas-to-liquid processes, Fischer Tropsch process • CO4: students know details of carbon dioxide capture and storage, they can calculate energy requirement students know details of desulfurization process						
Topics Covered	**Module I:** Fundamental concepts in understanding biofuel/bioenergy production; Climate Change & the Impact of Carbon Dioxide; History of Biofuels; Renewable Biomass feedstocks and its production; Feedstocks availability, characterization and attributes for biofuel/bioenergy production; Biomass pre-processing: drying, size reduction, and densification. [10 hrs]						

	Module II: Bio-ethanol, Bio-butanol: 1st Generation Biofuels – Corn Ethanol & Sugarcane Ethanol; 2nd Generation Biofuels – Cellulosic Ethanol; Different enzymes, enzyme hydrolysis, and their applications in ethanol production; 3rd Generation Aquatic Biomass – Cyanobacteria, Diatoms & Algae; Production Processes for Biofuels from Algae. [9 hrs] **Module III:** Biodiesel production from oil seeds, waste oils and microalgae, Transesterification process, feedstock processing, Reaction kinetics, Thermodynamics, Parametric optimization of transesterification, Catalyst and catalyst support development, reusability, characterization of catalyst and biofuel, safe disposal, cost estimation of biofuel and catalyst synthesis. [9 hrs] **Module IV:** Biogas & Biohydrogen; Microbial fuel cells; Gasification processes Advanced power plant concepts (IGCC); Fischer-Tropsch synthesis, gas to liquid processes. [8 hrs] **Module V:** Environmental impacts of biofuel production: Carbon dioxide capture and storage; Chemical Looping, Desulfurization; Value-added processing of biofuel residues and co-products. [6 hrs]
Text Books, and/or reference material	Suggested Text Books: 1. Biofuel Technology Handbook, Dominik Rutz, Rainer Janssen, WIP Renewable Energy, Germany, 2003 Suggested Reference Books: 1. Biofuel Technology: Recent Development, Reza Faryar, Springer Publishers, 2001 2. Biofuel and Bioenergy Technology, Wei-Hsin Chen, Keat Teong Lee, Hwai Chyuan Ong, MDPI, Switzerland, ISBN 978-3-03897-596-0 (Pbk)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	2
CO3	3	1	2
CO4	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

INTEGRATED MSC IN CHEMISTRY

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in ______ Senate # ________________ # Item no: _______

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

DEPARTMENT OF CHEMISTRY

Program Name: Int. M. Sc. in CHEMISTRY

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR Int. M. Sc. in CHEMISTRY.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26
Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CYC301	State of Matter and Chemical Thermodynamics	3	1	0	4.0	4
3	CYC302	Atomic Structure and Chemical Bonding	3	1	0	4.0	4
4	CYC303	Stereochemistry and Basic Principle of Organic Chemistry	3	1	0	4.0	4
5	PHC334	Physics - II	3	0	0	3.0	3
6	PHS384	Physics- II Laboratory	0	0	3	1.5	3
7	CYS351	Qualitative Analysis of Organic Samples Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25

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Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CYC401	Biochemistry: Structure and Function	3	0	0	3.0	3
2	CYC402	Phase-Equilibrium, Chemical Kinetics and Catalysis	3	1	0	4.0	4
3	CYC403	Chemistry of Elements and Radioactivity	3	1	0	4.0	4
4	CYC404	Organic Reaction Mechanism and Reactive Intermediates	3	1	0	4.0	4
5	YYO44*	Open Elective - 1	3	0	0	3.0	3
6	CYS451	Thermodynamic Properties of Solution and Mixture Laboratory	0	0	4	2.0	4
7	CYS452	Identification of Acidic and Basic Radicals Laboratory	0	0	4	2.0	4
8	CYS453	Biochemistry Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (optional)	0	0	0	0.0	0
		TOTAL	15	3	11	23.5	29
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CYC501	Fundamentals of Electrochemistry and Surface Chemistry	3	1	0	4.0	4
2	CYC502	Chemistry in Solution and Solid State Chemistry	3	1	0	4.0	4
3	CYC503	Chemistry of Heterocyclic Compounds and Natural Products	3	1	0	4.0	4
4	CYC504	Industrial Chemistry	3	0	0	3.0	3
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	CYS551	Chemical Kinetics, Surface Chemistry and Conductometry	0	0	3	1.5	3
7	CYS552	Quantitative estimation of metal ions in mixture	0	0	4	2.0	4
8	CYS553	Quantitative Analysis of Organic Samples	0	0	3	1.5	3
9	XXS581	Co-curricular Activities- V (optional)	0	0	0	0.0	0
		TOTAL	15	3	10	23.0	28
Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CYC601	Basics of Photochemistry, Spectroscopy, Group Theory and Data Analysis	3	1	0	4.0	4
2	CYC602	Coordination Chemistry	3	1	0	4.0	4
3	CYC603	Reagents in Organic Synthesis	3	1	0	4.0	4
4	CYE611/2	Departmental Elective-1	3	0	0	3.0	3
5	XEC631	Economics and Management Accountancy	3	0	0	3.0	3
6	CYS651	Potentiometric and Colorimetric Analysis	0	0	3	1.5	3
7	CYS652	Analysis of Ores and Alloys	0	0	4	2.0	4
8	CYS653	Single Step Synthesis of Organic Compounds	0	0	4	2.0	4
9	CYS654	Comprehensive Viva Voce - I	0	0	0	1.0	0
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	3	10	24.5	28

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Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	CYC701	Quantum Chemistry and Spectroscopy	3	1	0	4.0	4
3	CYC702	Inorganic Reaction Mechanisms and Magnetochemistry	3	1	0	4.0	4
4	CYC703	Concept of Organic Synthesis and Asymmetric Synthesis	3	1	0	4.0	4
5	CYC704	Mathematical and Computational Chemistry	3	0	0	3.0	3
6	CYS751	Spectrophotochemical Analysis	0	0	3	1.5	3
7	CYS752	Spectrophotometric Estimation of Cations and Anions	0	0	3	1.5	3
8	CYS753	Separation and Identification of Organic Compounds from Binary Mixture	0	0	4	2.0	4
		TOTAL	15	3	10	23.0	28

Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CYC801	Chemical, Statistical Thermodynamics and Electrochemistry	3	1	0	4.0	4
2	CYC802	Organometallic Compounds and Bioinorganic Chemistry	3	1	0	4.0	4
3	CYC803	Pericyclic Reactions and Organic Photochemistry	3	1	0	4.0	4
4	CYE811/2	Departmental Elective- 2	3	0	0	3.0	3
5	CYS851	Advanced Practical Physical Chemistry	0	0	4	2.0	4
6	CYS852	Synthesis and Characterisation of Complex Compounds	0	0	3	1.5	3
7	CYS853	Chromatographic Separation of Organic Compounds	0	0	3	1.5	3
		TOTAL	12	3	10	20.0	25

Semester - IX							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CYE9 --	Special subject -1	3	1	0	4.0	4
2	CYE9 --	Special subject -2	3	1	0	4.0	4
3	CYE9 --	Special subject -3	3	1	0	4.0	4
4	CYE9 --	Special subject -4	3	1	0	4.0	4
5	CYS9 --	Special subject Sessional	0	0	3	1.5	3
6	CYS954	Project- I	0	0	3	1.0	4
7	CYS955	Vocational training/ Summer internship/ Term Paper	0	0	0	1.0	0
8	CYS956	Comprehensive Viva Voce - II	0	0	0	1.5	0
		TOTAL	12	4	07	21.0	23
Semester - X							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	CYS1051	Project – II/ Internship	0	0	30	10.0	30
2	CYS1052	Seminar & Viva voce	0	0	0	2.0	0
		TOTAL	0	0	30	12.0	30

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

CREDIT UNIT OF THE PROGRAM:

Semester	**I+II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**Total**
Credit units	**44.0**	**22.0**	**23.5**	**23.0**	**24.5**	**23.0**	**20.0**	**21.0**	**12.0**	**213.0**

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

SIXTH SEMESTER	
CYE611	Analytical and Environmental Chemistry
CYE612	Chromatographic Separation and Instrumental Methods of Analysis

EIGHT SEMESTER	
CYE811	Advanced Natural Products and Medicinal Chemistry
CYE812	Spectroscopic Methods of Chemical Analysis

NINTH SEMESTER	
CYE911	Advanced Quantum Chemistry and Application of Group Theory
CYE912	Non-Equilibrium Thermodynamics and Biophysical Chemistry
CYE913	Material chemistry and advanced spectroscopy
CYE914	Electrode kinetics and corrosion science
CYS951	Advanced Physical Chemistry-II Laboratory
CYE921	Advanced Green Chemistry and Analytical Chemistry
CYE922	Synthetic Methodology for Metal Complexes and Coordination Aggregates
CYE923	Small Molecule Activation, Nuclear Chemistry and Related Spectroscopy
CYE924	Group theory, applied electrochemistry and X-ray structure analysis
CYS952	Environmental Sample Analysis
CYE931	Application of some important reactions in synthetic organic chemistry
CYE932	Natural Products and Drug Design
CYE933	Bioorganic Chemistry
CYE934	Advanced Stereochemistry and structure activity Correlation
CYS953	Multi Step Synthesis and characterization of Organic Compounds

DETAILED SYLLABUS

FIRST SEMESTER

Semester - I							
Sl. No	Code	Subject	L	T	S	C	H
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points,						

	Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC 01</td><td>Engineering Chemistry</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications
• CO2: To learn fundamentals of polymer chemistry and petroleum engineering.
• CO3: Introduced to basic spectroscopic techniques for structure determination and characterization.
• CO4: To study few inorganic and bioinorganic compounds of industrial importance.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">ORGANIC CHEMISTRY
i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb’s catalyst and Wittig reaction. (3)
ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3)
iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2)
iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)
v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3)
INORGANIC CHEMISTRY
i. Coordination Chemistry: Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5)</td></tr>
</table>

	ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1

	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues. • CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XES51</td><td>ENGINEERING GRAPHICS</td><td>PCR</td><td>1</td><td>0</td><td>3</td><td>4</td><td>2.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
</table>

Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	Professional Communication Lab	PCR	1	0	2	3	2
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
None			CT+EA				
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)						
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.						
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil						
	<u>Suggested Text Books:</u> 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra <u>Suggested Reference Books:</u> 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
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<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)#</th><th>Total Hours</th></tr>
<tr><td>WSS51</td><td>WORKSHOP PRACTICE</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
• CO1: Study and practice on machine tools and their operations
• CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
• CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
• CO4: Develop basic electrical engineering knowledge for house wiring practice
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
M/c shop & Carpentry shop -- 3X3= 9hrs.
• Introduction on machining process.
• Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
• Introduction to woods- Types, structure, disease and defect of wood.
• Introduction to wood working machines and tools.
• Making of dovetail joint and bridle joint.
Welding Shop & Sheet metal -- 3X3= 9hrs.
• Introduction to welding.Safety and precautions in welding.
• Formation of weld bead by SMAW on mild steel flat.
• Formation of weld bead by oxy-fuel welding on mild steel flat.
• Introduction to sheet Metal works.
• Tools and Machines used in sheet metal works.
• Concept of development, marking out of metal sheets.
• Cutting and joining of metal sheets.
• Safety precautions, General warning needed in the shop floor.
Black smithy & Foundry -- 3X3= 9hrs.
• Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
• Safety and precautions in blacksmithy.
• Making of bars of different cross-sections.
• Making of hexagonal headed bolts.
• Forge welding.
• Introduction to Foundry Technology.
• Preparation of sand mould using Solid/Split Pattern.
Fitting & Electrical shop -- 3X3= 9hrs.
• Introduction to hand metal cutting tools with specifications, nomenclature and their use.
• Marking tools, measuring tools and their use.
</td></tr>
</table>

	• Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana,						

	Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick.

	• Rules and their interpretation. **CRICKET** • Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense& Drive. • Batting Back foot defense& Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With

	stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 02	MATHEMATICS - II	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Basic concepts of set theory, differential equations, and probability.	CT+MT+EA

Course Outcomes	
	• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems. • CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations. • CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work. • CO4: To grasp the basic concepts of probability theory.

Topics Covered	**Elementary algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (5) **Linear Algebra:** Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15) **Ordinary Differential Equations:** Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
	Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10thed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC01</td><td>INTRODUCTION TO COMPUTING</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of computer.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software’s (operating Systems) and application software’s, languages, number system, logic gates.
CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators.
CO3: Develop conditional and iterative statements to write C programs.
CO4: Exercise user defined functions to solve real time problems
CO5: Inscribe C programs that use Pointers to access arrays, strings and functions.
CO6: Exercise user defined data types including structures and unions to solve problems.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2]
Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1]
Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2]
Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1]
C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2]
Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8]
Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5]
Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5]
Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10]
Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC01</td><td>Basic Electronics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">(10+2) level mathematics and physics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Knowledge of Semiconductor physics and devices.
• CO2: Have an in depth understanding of basic electronic circuit, construction, operation.
• CO3: Ability to make proper designs using these circuit elements for different applications.
• CO4: Learn to analyze the circuits and to find out relation between input and output.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Semiconductors
1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium
1.2. Definitions of insulator, conductor and semiconductor using band diagram
1.3. Crystalline structure of semiconductor
1.3.1. Covalent bond</td></tr>
</table>

	1.3.2. Generation of holes and electrons 1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.)

	7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	<u>Text Books</u>: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. <u>Reference Books</u>: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEC01</td><td>ELECTRICAL TECHNOLOGY</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.
• CO4: introduce the basic concept of single-phase transformer.
• CO5: analyze the transient phenomena in electrical circuits with DC excitation.</td></tr>
</table>

Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	1	1
CO2	3	3	3	3	2	1	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC01</td><td>LIFE SCIENCE</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism.
CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa
CO3: To introduce molecular biology to understand biological processes in various applications.
CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens.
CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Cell Biology (4)
a) Introduction to life science: prokaryotes & eukaryotes
Definition; Difference
b) Introduction to cells - Define cell, different types of cell
c) Cellular organelles - All organelles and functions in brief
d) Cellular communications
Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation
2. Biochemistry (4)
a) Biological function of carbohydrate and lipid - Introduction, structure and function
b) Biological function of nucleic acids and protein - structure and function
c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids
d) Biosynthesis of Macromolecules
Generation of ATP (ETS), Generation of Glucose (Photosynthesis)
3. Microbiology (5)
a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases
b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc,
c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve
d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle</td></tr>
</table>

	4. Immunology (5) a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)... Engineering Drawing and Graphics – K Venugopal 2)... AutoCAD — George Omura 3)... Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques						

	• CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output signals.						

Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	Upon successful completion of this course, the student should be able to •CO1: understand the principle of superposition.						

	•CO2: understand the principle of maximum power transfer •CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. •CO4: understand the calibration of energy meter. •CO5: understand open circuit and short circuit test of single-phase transformer. •CO6: analyze RLC series and parallel circuits •CO7: understand three phase connections. •C08: understand determination of B-H curve
Topics Covered	**List of Experiments:** 1. To verify Superposition and Thevenin's Theorem. 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit 9. Determination of B-H Curve for magnetic material
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma , H U Ezea 2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XXS-52	Co-curricular Activities	PCR	0	0	2	2	1

Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)
NIL	CE + EA
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike. • Block- Single block, Double block, Triple block, Group block.

	• Field Defense- Dig pass, Double pass, Roll pass. • Rules and their interpretation. **FOOTBALL** • Dribbling- Square pass, Parallel pass, Forward pass. • Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading. • Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe). • Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc. • Feinting- Body movement to misbalance the opponent and find space to go with ball. • Rules of Football. **CRICKET** • Batting straight drive. • Batting pull shot. • Batting hook shot. • Bowling good length, In swing. • Bowling out swing, Leg break, Goggle. • Fielding drill. • Catching (Long & Slip). • Wicket keeping technique. • Rules & Regulation. **BADMINTON** • Net play- Tumbling net shot, Net Kill, and Net Lift. • Smashing. • Defensive high clear/Lob. • Half court toss practice, Cross court toss drop practice, Full court Game practice. • Player Positioning, Placements. • Rules & Regulation. • Doubles & Mixed doubles match practice. **TABLE TENNIS** • Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin. • Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin. • Service: Backhand/Forehand- Push service, Deep push service, Rally service. • Service: Backhand sidespin (Left to right & Right to left). • Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles).

	NCC • FD-6 Side pace, Pace Forward and to the Rear. • FD-7 Turning on the March and Wheeling. • FD-8 Saluting on the March. • FD-9 Marking time, Forward March and Halt in Quick Time. • FD-10 Changing step. • FD-11 Formation of Squad and Squad Drill. • FD-12 Parade practice. **TAEKWONDO** • Poomsae (Forms)- Jang, Yi Jang. • Self Defense Technique- Self defense from arms, Fist and Punch. • Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring). • Combination Technique- Combined kick and punch. • Board Breaking (Kyokpa)- Sheet breaking. • Interpretation Rules above Technique of Taekwondo. **NSS** • No Smoking Campaign • Anti- Terrorism Day Celebration • Any other observation/celebration proposed by Ministry/institute • Public Speaking • Discussion on Current Affairs • Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

THIRD SEMESTER

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td>MATHEMATICS-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of topics included in MAC01 & MAC02.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]
Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14]
Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement</td></tr>
</table>

	only); Singular points and residues; Cauchy's residue theorem. [17] **Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	Suggested Text Books: 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar&R.K.Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig Suggested Reference Books: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2		2			2	2	3
CO2	1	2	1	1			3		2	1		3
CO3	3			2		1	2		2			3
CO4	3	3	3	2			1	2	1		2	3

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC301	**State of mater and chemical thermodynamics**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA))					

<table>
<tr><td colspan="2">NIL</td><td colspan="2">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="3">CO1: Foundation in chemical thermodynamics.
CO2: Understand the fundamental properties of different states of matter.
CO3: Analyzing effect of various experimental parameters towards equilibrium condition of a chemical reaction/process.
CO4: Numerical analysis on various thermodynamics properties.</td></tr>
<tr><td>Topics Covered</td><td colspan="2">Kinetic Theory of Gases and Real gases
a. Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion.
b. Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases
c. Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states
d. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only)
Liquids
Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)
Solids
Forms of solids, crystal systems, unit cells, Bravis lattice types, Symmetry elements; Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl (qualitative treatment only); Defects in crystals; Glasses and liquid crystals</td><td>4L

6L

4L

2L

6L

6L</td></tr>
</table>

	Chemical Thermodynamics Second law and its elementary interpretation, Carnot's cycle and theorems, Refrigeration, Concept of entropy, Clausius inequality Gibbs and Helmholtz functions, Criteria of spontaneity, Thermodynamic probability, Thermodynamics equation of states; Thermodynamic relations; Thermodynamics of ideal mixing, Clausius-Clayperoneqn and phase diagram of single component systems, Joule-Thomson cooling effect. **Chemical Equilibrium** Conditions of spontaneity and equilibrium, degree of advancement and Le Chatelier principle; Van't Hoff isotherm, isobar and isochore systems. Various factors affecting the equilibrium condition.	14L 4L
Text Books, and/or reference material	1. Physical chemistry by P. Atkins and J.de Paula 2. Physical chemistry by Laidler and Meiser 3. A text book of physical chemistry by K.L.Kapoor (Vol 1 and 2) 4. Physical chemistry by P.C.Rakshit 5. Physical Chemistry by Barrow, G.M. Tata McGraw-Hill (2007)	

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	2	1	1	3	2	1	1	2
CO2	3	1	1	3	2	1	1	3	2	1	1	2
CO3	3	1	1	3	2	1	1	2	2	1	1	2
CO4	3	1	1	3	1	1	1	1	1	1	1	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC302	**Atomic structure and Chemical bonding**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Course Outcomes	• CO1: know the history of development of the subject with the contribution of the scientist. • CO2: to be exposed with quantization of energy, momentum and space. • CO3: understand the behavior of electron in an atom in term of energy, momentum, position etc. • CO4: knowledge about the hydrogen spectrum in absence and presence of magnetic field. • CO5: know about Schrodinger equation and different quantum number. • CO6: spin of electrons and spin quantum number • CO7: orientation and shape of the atomic orbitals • CO8: quantum mechanical treatment of VB and MOT • CO9: understand the concept of hybridization of atomic orbital, the shape of the molecules, VB and MOT	
Topics Covered	Genesis: Planks quantisation of energy, photoelectric effect, Compton effect, De Broglie wave particle duality, Heisenberg uncertainty principle, wave function, Born interpretation	04
	Schrödinger wave equation of hydrogen atom, separation of variables, quantum numbers, Principal quantum number, orbital quantum numbers, magnetic quantum numbers, shape and size of orbital, uncertainty principal and quantisation of space	04 04
	Electron probability density, radial part, radial distribution curve and its interpretation, node and angular part of wave s (imaginary and real form) and orbitals shape, electron cloud density representation of hydrogen orbitals	02
	Electron in magnetic field, Zeeman effect, spectrum of hydrogen atom and electron spin	02
	Many electron atoms and ions: Antisymmetric principle, Pauli's exclusion principle, Hund's rule, exchange energy, Aufbau principle	04
	Electronic energy level diagrams and electronic configurations of hydrogen-like and poly electronic atoms and ions, screening effect, Slater rule, approximate method, variation principle, spin orbit coupling, term symbol	01 02 05
	Covalent bond: Covalence bond: Lewis structure and octet rule, violation of octet rule Variation principle, one electron wave function, valence bond theory with H_2 Hybridisation, sigma bond, pi bond, delta bond, bond distance, bond energies, bond angle Directional property, shape, VSEPR	02

	Bond moment and dipole moments, hydrogen bond, inter molecular forces Molecular orbital theory, H_2^+, binuclear(AB) , tri nuclearAB$_2$ (linear and angular), Cyclic planar, Penta nuclearAB$_4$ (tetrahedral, square planer) , hepta nuclear AB$_6$ (octahedral) etc.	02 05
Text Books, and/or reference material	1. Inorganic Chemistry, Part I , R. L. Dutta New Book Stall 2. Fundamental concept of Inorganic Chemistry, vol I and II, Asim K. Das, CBS publishers & distributors 3. Inorganic Chemistry, Huheey, Keiter, Keiter, Medhi, Pearson education 4. Inorganic chemistry, Shriver & Atkins, Oxford 5. Concept and models of inorganic Chemistry, Douglas, Mcdeniel, Alexander, Wiley india Pvt. Ltd.	

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	1	1	2	1	2	2	1
CO2	3	2	3	3	--	1	1	2	1	2	2	1
CO3	3	2	3	3	--	1	--	2	1	2	2	1
CO4	3	2	3	3	--	1	1	2	1	2	2	1
CO5	3	2	3	3	--	1	1	2	1	2	2	1
CO6	3	2	3	3	--	1	1	2	1	1	2	1
CO7	3	2	3	3	--	1	--	2	1	2	2	1
CO8	3	2	3	3	--	1	1	2	1	2	2	1
CO9	3	2	3	3	--	1	1	2	1	1	2	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 303	**Stereochemistry and Basic principle of organic chemistry**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Course Outcomes	• CO1: To Learn Basic Concept of stereochemistry • CO2: To Learn Molecular symmetry, Designation of chiral centre, axis and helices • CO3: To Learn Selectivity issues in organic reactions • CO4: To Learn Nomenclature of bicyclic and Spiro compounds and reactivity based on stereochemistry • CO5: To Learn Conformational analysis • CO6: To Learn Chemistry of Functional Groups	
Topics Covered	1. Basic concept of stereochemistry : Isomerism; asymmetric and dissymmetric centres /molecules, Conformation and configurational nomenclature 2. Molecular symmetry: chirality, chiral axis, helicity, 3. Regio-, chemo- and stereoselective reactions 4. Nomenclature of spiro and bicyclic compounds, reactivit6y based on stereochemistry	25 lecs
	5. conformational analysis of acyclic and cyclic compounds 6. Chemistry of functional groups: Preparation, properties, reactions, separation and identification of compounds containing various functional groups	15Lecs
Text Books, and/or reference material	1. Basic stereochemistry of organic molecules: S. Sengupta 2. Stereochemistry: Conformation and Mechanism; P.S. Kalsi 3. Organic Chemistry : Morrison and Boyd 4. Organic stereochemistry: D. Nasipuri **5. Stereochemistry of Carbon Compounds: Ernest L. Eliel.** 6. Organic Chemistry : S. H. Pine	

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	2	2	3	3	1	3	2
CO2	3	3	3	3	1	2	3	3	3	1	3	2
CO3	3	3	3	3	3	3	2	3	3	3	3	3
CO4	3	3	3	3	1	1	2	3	3	1	3	2
CO5	3	3	3	3	2	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS351	**Qualitative analysis of organic samples**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods: Continuous assessment and Viva-Voce at the end of the semester.					
None							
Course Outcomes	• CO1: A basic idea about the physical methods like; M.P., B.P., distillation and crystallization for analysis of organic compounds. • CO2: An idea about the uses of reagents and solvents for analysis of organic compounds • CO3: Detection and identification of special elements and functional groups of organic samples.						
Topics Covered	1. **Mixed Melting Point Determination:** Urea – Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1) 2. **Distillation**: Simple distillation of ethanol-water mixture using water condenser Distillation of nitrobenzene and aniline using air condenser Purification of common organic solvents by distillation; methanol, petroleum ether, THF, chloroform etc. 3. **Crystallization**: Concept of induced crystallization, Phthalic acid from hot water (using fluted filter paper and stem less funnel), Acetanilide from boiling water, Naphthalene from ethanol, Benzoic acid from water. 4. **Decolourization and Crystallization:** Decolourization of brown sugar (sucrose) with animal charcoal using gravity filtration. Crystallization and decolourization of impure naphthalene (100 g of naphthalene mixed with 0.3 g of congo red using 1 g decolourizing carbon) from ethanol. 5. **Sublimation (Simple and vacuum)**: Camphor, Naphthalene, phthalic acid and Succinic acid. 6. **Identification of some common organic molecules:** methanol, ethanol, acetone, glycerol, aniline, nitrobenzene, benzyl alcohol, formic acid, acetic acid, succinic acid, tartaric acid, salicylic acid, glucose, sucrose, resorcinol. 7. **Identification of unknown organic compound:** Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.						

Text Books, and/or reference material	Suggested Text Books: (i) Textbook of Practical Organic Chemistry by Vogel (ii) A text-book of practical organic chemistry by Subhas C Das (iii) A text book on chemistry practical: Nad, Mahapatra and Ghosal

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	2	2	3	3	2	3	2
CO2	2	3	3	3	2	2	3	2	3	3	2	2
CO3	3	3	3	2	1	3	2	3	2	2	1	2

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC334	**Physics II**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Able to understand the principles of classical mechanics apply to solve classical problems related to solving Lagrange's and Hamilton's equations of motion. CO2: Able to apply fundamental knowledge of different co-ordinate systems to describe the spatial variations of the physical quantities dealt in electromagnetic field theory. CO3: Able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.). CO4: Gain an integrative overview of electromagnetic waves, its propagation in different media and different phenomena related to electromagnetic wave propagation..						

Topics Covered	**Classical Mechanics**: D'Alembert's principle, Lagrange's equation of motion, Some applications of Lagrange's equation of motion, Hamilton's equation of motion, Some applications of Hamilton's equation of motion and its physical significance [6L] **Vector Analysis**: Vector field, Divergence and curl of a vector field and their physical significance, Gauss's divergence theorem, Stoke's theorem, Green's theorem, Different coordinate systems (Cartesian, spherical and cylindrical) [8L] **Electrostatics**: Divergence of electrostatic field, Gauss's Law of electrostatics and its applications, Laplace's equation, Poisson's equation, Continuity equation, Capacitor. [6L] **Magnetostatics**: Curl of magnetic field, Ampere's Circuital law and its applications, Curl of electric field and divergence of magnetic field, Concepts of scalar and vector potentials. [7L] Electromagnetic Induction and Maxwell's Equation: Faraday's law of electromagnetic induction, Concept of displacement current, Maxwell's equation in free space, Poynting Theorem. Some examples. [7L] **Alternating Current**: L-R, C-R, L-C-R series and parallel circuits, Q- factor, Resonance, Maximum power transfer theorem, Voltage magnification factor, Band width of circuit. [8L]
Text Books, and/or reference material	**TEXT BOOK**: 1. Vector Analysis: Murray Spiegel (Author),Seymour Lipschutz, Dennis Spellman 2. Introduction to Electrodynamics: David J. Griffith 3. Introduction to Classical Mechanics: R. G. Takwale & P. S. Puranik **REFERENCE BOOKS**: 1.Classical Mechanics: N. C. Rana & P. S. Joag 2.Classical Mechanics: H. Goldstein 3. Electricity and Magnetism: D. Chattopadhyay & P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC334	CO1	3	2	1	2		1	1		1	1		1
	CO2	3	2		1	1				2	1		1
	CO3	3	2	1	1		1			1	1		1
	CO4	3	2	1	1		1	1		2	1		1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS384	**Physics II Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
PHS51		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring resonance, Q-factor of series L-C-R circuit. CO2: To determine the Self-Inductance, Mutual Inductance and verification of Faraday's law. CO3: To determine the thermoelectric power of a given thermocouple. CO4: To apply the concepts to measure the horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer CO5: To calculate the loss of a magnetic specimen by B-H loop measurement.
Topics Covered	1. Study of series L-C-R Resonant Circuit: (i) To draw the resonance curve (ii) To determine the Q- Factor of the circuit (iii) To study the variation of impedance with frequency (iv) verification of maximum power transfer theorem. 2. Verification of Faraday's law. 3. To determine the Mutual-Inductance (M-I) of two coils. 4. Determination of Self-Inductance of a coil. 5. To verify Fresnel's equation for reflection of electromagnetic waves. 6. Draw the (Thermo EMF) – Temperature curve of given thermocouple and hence find thermoelectric power at a given temperature. 7. Determination of horizontal component of the earth's magnetic field using a vibrational and deflection magnetometer. 8. To draw the B-H loop of a given specimen.
Text Books, and/or reference material	**SUGGESTED BOOKS:** 1) A Text Book on Practical Physics – K. G. Majumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS382	CO1	3	2	1		2	1	1	2	3	2	1	1
	CO2	3	2	1		2	1	1	2	3	2	1	1
	CO3	3	2	1	1	2	1	1	2	3	2	1	1
	CO4	3	2	1		2	1	1	2	3	2	1	1
	CO5	3	2	1	1	1	1	1	1	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

Department of Chemistry								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC401	**Biochemistry: Structure and Function**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	• CO1: Understanding the Chemistry behind biological processes • CO2: Development of basic knowledge of cell structure and function • CO3: Learning of different chemical aspects of biomolecules such as Carbohydrates, Lipids, Proteins, Nucleic acids • CO4: Generation of concepts on molecular mechanics amongst biomolecules as a stepping-stone towards Biophysical Chemistry.	
Topics Covered	1. Amino Acids and Protein Chemistry: Introduction, classification according to their composition. Different methods of peptide synthesis. Different methods to determine the composition of peptides and proteins (amino acid analysis). Primary and secondary structure of proteins. Denaturation of proteins. Different methods of molecular weight determination	10
	2. Chemistry of mono, di, oligo and poly-saccharides Introduction, Conformation of monosaccharides, structure and functions of important monosaccharides like glycosides, deoxy sugars, myoinositol amino sugars. N-acetylmuramic acid, sialic acid, disaccharides and polysaccharides. Structural polysaccharides – cellulose and chitin. Storage polysaccharides - starch and glycogen.	6
	3. Lipid chemistry Introduction, , Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, Properties of lipid aggregates – micelles, bilayers, liposomes and their possible biological functions. Biological membrane. Fluid mosaic model of membrane structure, Iodine number	5
	4. Structure and function of DNA and RNA, nucleosides, nucleotides, Introduction, Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Structure of RNA and DNA, double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The chemical basis of heredity, an overview of replication of DNA, transcription, translation and genetic code.	12

Text Books, and/or reference material	1. Principles of Biochemistry by Lehninger 2. Biochemistry byVoet&Voet. 3. Principles of Physical Biochemistry by K. E. van Holde, C. Johnson and P. S. Ho (Pearson).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	2	2	3	3	1	3	2
CO2	3	3	3	3	1	2	3	3	3	1	3	2
CO3	3	3	3	3	3	3	2	3	3	3	3	2
CO4	3	3	3	3	1	1	2	3	3	1	3	2

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC402</td><td>Phase-equilibrium, chemical kinetics and catalysis</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment) (EA)</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcome</td><td colspan="7">• CO1: Concept of phase rule and phase diagram of multi-component system.
• CO2: Understand the fundamentals of chemical kinetics and corresponding theoretical treatment.
• CO3: Concept of catalysts towards reaction rate and its applications.
• CO4: Numerical analysis of the effect of various parameters on reaction kinetics.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Phase rule and phase diagram:
Phase rule equation (derivation excluded); phase diagram of water and sulphur system, Two component system, Miscibility (phenol-water) and distillation of completely miscible binary liquid mixtures; azeotropes, Steam distillation. 10L
Colligative properties:
Raoult’s law of vapour pressure and colligative properties: osmosis, lowering of freezing point, elevation of boiling point, experimental methods of determination of molecular weights of substances in dilute solutions, van’t Hoff ‘i’ factor and abnormal behaviour of electrolytic solutions. 10L</td></tr>
</table>

	Chemical Kinetics: Rate process approach towards complex reactions including Opposing reaction, parallel reaction, consecutive reactions chain reactions; Pseudo first order reactions; Determination of order of a reaction by half-life and differential method. 8 L Temperature dependence of rate constant; Arrhenius equation, energy of activation Lindemann theory of unimolecular reaction. Collision theory; Transition State theory. Effect of ionic strength (primary and secondary salt effect), dielectric constant and pressure on rate. Kinetics of different composite reactions, including Auto-catalytic and Oscillating reactions. 10L **Catalysis:** Rate expressions for Homogeneous and heterogeneous catalytic reactions including acid-base catalyzed reaction, bimolecular surface catalyzed reaction, and enzyme catalyzed reactions. Determination of turnover number of an enzyme. 6 L
TextBooks,	1. Physical chemistry by P. Atkins and J.de Paula 2. Physical chemistry by Laidler and Meiser 3. A text book of physical chemistry by K.L. Kapoor 4. Physical chemistry by P.C.Rakshit 5. Physical Chemistry by Barrow, G.M. Tata McGraw-Hill (2007) 6. Physical Chemistry by Castellan, G.W. 4th Ed. Narosa (2004) 7. Chemical kinetics by K.J. Laidler

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	2	1	1	3	2	1	1	2
CO2	3	1	1	3	2	1	1	3	2	1	1	2
CO3	3	1	1	3	2	1	1	3	2	1	1	2
CO4	3	1	1	3	2	1	1	2	2	1	1	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC403	**Chemistry of Elements and Radioactivity**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NIL		CT+EA					

Course Outcome	• CO1: Knowledge of periodic properties and their variation in period and group.. • CO2: General trends of elements and their compounds for s, p, d and f block elements. • CO3: knowledge the structure and function of s, p, d and f block elements. • CO4 : Concept of radioactive nuclei and their properties • CO5 : Measurement of radioactivity • CO6 : Various uses of radioactive elements
Topics Covered	**Periodic property:**Ionisation enthalpy, electronegativity, electron gain enthalpy, atomic radius, ionic radius van der waals radii etc. and their variation in period and group. 5 lec **s block element:** general trends of elements and their compounds: Hydrides, oxides halides and other salts 2 lec **p block elements:**general trends of elements and their compounds: Hydrides, oxides, oxyacids halides and other important compounds Structure and bonding of boranes, , carboranes, silicones, silicates, boron nitride, borazines and phosphazenes, allotropes of carbon phosphorous, sulphur, carbides, nitrides, pseudo-halogens, and interhalogen compounds, chemistry of noble gases,10 lec **d block and f block elements and their compounds**: General characteristics of elements, size, oxidation states and their stabilisation, hydride, oxides and hydroxides, halides etc. 5 lec **Radioactivity:** Discovery of Radioelement, Nature of radiations, Characteristics of Alpha, Beta, Gamma rays and positrons 2 lec Nuclear versus chemical reactions, Radioactive decay and recovery, Theory of radioactive disintegration, Cause of Radioactivity, Disintegration series and group displacement law. 3 lec Measurements of radioactivity, Rate of radioactive decay, Determination of decay constant and half-life, Determination of average life, Radioactive equilibrium, numerical problems 4 lec Artificial transmutation, cyclotron, Artificial radioactivity, Man-made element, Syntheses of Actinide elements 2 lec Isotopes, isobars, isobaric isotopes and isotones, Methods of isotope preparations: Diffusion method, Thermal diffusion method, Evaporation and distillation method, electrolytic method, Szilard-Chalmers method 3 lec Uses of isotope: Medicinal uses, uses in analytical chemistry (activation analysis, isotope dilution analysis), Uses to study reaction mechanism, uses to age determination, Agricultural uses, Numerical problems 3 lec Nuclear Fission, Nuclear fusion, nuclear spallation, Nuclear binding energy and packing fraction, Nuclear binding forces, Nuclear shell model: Magic number 3 lec

Text Books, and/or reference material	1) Inorganic Chemistry, Part I/II, R.L. Dutta, New Book Stall 2) Inorganic chemistry, Shriver & Atkins, Oxford 3) Concise inorganic chemistry, Lee, Wiley India Pvt. Ltd. 4) Advanced Inorganic Chemistry, Cotton & Wilkinson, John Wiley 5) Essentials of Nuclear Chemistry, H. J. Arnikar, New Age International Publishers, 2009

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	2	2	3	3	2	1	1
CO2	2	2	3	2	2	2	2	3	3	1	1	1
CO3	2	3	3	2	2	2	2	3	3	3	1	1
CO4	2	2	3	2	2	2	2	3	3	2	1	1
CO5	3	2	3	2	2	2	2	3	3	3	1	1
CO6	3	2	3	2	2	2	2	3	3	3	1	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 404	**Organic Reaction Mechanism and Reactive Intermediates**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To Learn methods for investigating of organic reaction mechansims • CO2: To Learn various aspect of Elimination treactions • CO3: To Learn various aspects of addition reactions to C-C multiple bonds • CO4: To Learn synthetically useful addition reactions to C-hetero multiple bonds • CO5: To Learn the fundamentals of nucleophilic and electrophilic substitution reactions • CO6: To learn basics of some molecular rearrangements and their application in synthesis • CO7: To learn structure and reactivity of organic reactive intermediates						
Topics Covered	1. Methods for investigation of mechanism: Factors affecting the rate of reactions, activation energy, transition state, reactive intermediates, rate determining step, Hammond's postulate, product analysis, detection, isolation and trapping of intermediates, application of isotope—isotope labelling, primary kinetic isotope effect, secondary kinetic isotope effect, cross over experiment 2 Lecs.						

	2. Elimination reactions: E1 , E2, and $E1_{CB}$ mechanism, effect of stereochemistry, regioselectivity, isotope and stereo electronic effects effect 4 Lecs 3. Addition to C-C multiple bonds : Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, Hydrogenation of double, triple bonds and aromatic rings. Hydroboration reaction, Sharpless asymmetric epoxidation. 3 Lecs. 4. Addition to Carbon- Hetero Multiple Bonds: Mechanism of metal hydride reaction of substituted and unsubstituted carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organo-Zn and organo-Li and organo Si reagents to saturated and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation involving enolates5 Lecs. 5. Reaction mechanism of electrophilic and nucleophilic substitution: Substitution on sp^3 system, Electrophilic attack on benzene, π- and σ-complexes, electronic effect of substituents, ortho/para ratio, partial rate factors and selectivity, kinetic and thermodynamic control, nitration, halogenations, sulphonation, alkylation and acylation, diazo coupling, ipso substitution, nucleophilic attack on benzene system: substitution of hydrogen and atoms other than hydrogen, reactions via aryne intermediate, reactions and reactivity pattern in condensed aromatic sysyems 10 Lecs 6. Reaction mechanism of some rearrangement reactions: Allylic rearrangement, neopentyl rearrangement, pinacol-pinacolone, Beckmann, Wolff, Hofmann, Curtius, lossen and Schmidt rearrangement, benzyl-benzilic acid rearrangement, Bayer-Villiger oxidation 6 Lecs. 7. Chemistry of reactive intermediates: Formation, structure, stability , detection and reactions of carbocations, radicals, carbenes, nitrenes, carbions, arynes10 Lecs
Text Books, and/or reference material	1. A Guidebook to Mechanism in Organic Chemistry: Peter Sykes 2. Organic Chemistry: Subrata Sengupta 3. AdVanced General Organic Chemistry: A Molecular Approach: Sachin Kumar Ghosh 4. Organic Chemistry: G. Marc Loudon 5. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure: Michael B. smith

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	3	3	2	1	3	3
CO2	3	3	3	3	2	2	3	3	2	1	3	3
CO3	3	3	3	3	2	3	3	3	3	2	3	3
CO4	3	3	3	3	2	3	3	3	3	2	3	3

CO5	3	3	3	3	1	3	3	3	3	1	3	3
CO6	3	3	3	3	1	3	3	3	3	1	3	3
CO7	3	3	3	3	1	3	3	3	3	1	3	3

CYS451	**Thermodynamic Properties of Solution and Mixture Laboratory**	PCR (Practical)	**L** 0	**T** 0	**P** 4	**H** 4	**C** 2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA)and Viva-Voce)					
NIL		CT + Viva-voce					
Course Outcome	● CO1: Characterization of thermodynamic parameters. ● CO2: Evaluation of fundamental properties of liquids. ● CO3: Interpreting molecular interaction. ● CO4: development of laboratory skill, data handling and interpretation, error analysis.						
Topics Covered	1. Determination of partition coefficient of a solute between an organic solvent and water 2. Determination of equilibrium constant of a reaction $KI+I_2 \leftrightarrow KI_3$ 3. Determination of CST of phenol-water system 4. Determination of heat of solution of Benzoic acid 5. Experiment on viscosity measurement 6. Experiment on surface tension measurement 7. Determination of solubility product of PbI_2 8. Determination of specific rotation of cane sugar Any other practical as assigned by the Instructor						
Reference material	1. Instruction manual provided by the Instructor 2. Selected experiments in Physical Chemistry By N.G.Mukherjee 3. Advanced Physical Chemistry Experiments: By Gurtu & Gurtu						

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	1	1		2	1	1	2	1
CO2	3	1	1	3	1	1		2	1	1	2	1
CO3	3	1	1	3	1	1		2	1	1	3	1
CO4	1	1	1	3	1	1		2	2	1	2	1

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYS452</td><td>Identification of acidic and basic radicals</td><td>PCR (Practical)</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+ Viva voce</td></tr>
<tr><td colspan="2">Course Outcome (The students will master the following)</td><td colspan="6">Course outcome accounts of
● CO1: knowledge of elementary physical properties of cations and anions
● CO2. knowledge of dry reactions of cations and anions
● CO3: knowledge of different wet chemical reactions of cations and anions.
● CO4: reactions of interfering radicals and their removal process
● CO5: group separation of cations.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Qualitative inorganic analysis of mixtures
Cation Radicals: Na^+, K^+, Ca^{+2}, Sr^{+2}, Ba^{+2}, Al^{+3}, Cr^{+3}, Mn^{+2}, Fe^{+3}, Co^{+3}, Ni^{+3}, Cu^{+2}, Zn^{+2}.
Anion Radicals: F^-, Cl^-, Br^-, BrO_3^-, I^-, SCN^-, S^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, NO_3^-, NO_2^-, PO_4^{3-}, BO_3^{3-},CrO_4^{2-}/ $Cr_2O_7^{2-}$, $[Fe(CN)_6]^{4-}$, $[Fe(CN)_6]^{3-}$.
Insoluble Materials: Al_2O_3, Fe_2O_3, Cr_2O_3, SnO_2, $SrSO_4$, $BaSO_4$.
.</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="6">1. Text book of qualitative inorganic analysis by A.I Vogel
2. Practical Inorganic Chemistry by A.K.De and A.K Sen</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	3	3	2	2	1	3	3	3	1	1
CO2	2	2	3	3	2	1	1	3	3	3	1	1
CO3	1	3	3	3	2	2	1	3	3	3	1	1
CO4	3	3	3	3	2	2	1	3	3	3	1	1
CO5	3	2	3	3	2	3	1	3	3	3	1	1

CYS453	**Biochemistry Laboratory**	PCR (Practical)	**L** 0	**T** 0	**P** 3	**H** 3	**C** 1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA)and Viva-Voce)					
NIL		CT + Viva-voce					
Course Outcome (The students will well-acquainted with)	• CO1: development of laboratory skill, data handling and interpretation, error analysis • CO2: Characterization of biomolecules such as proteins, vitamin based on biophysical means • CO3: Estimation of amino acid, vitamin from unknown sample • CO4: Dealing and extraction of natural products						
Topics Covered	1. Estimation of protein 2. Estimation of carbohydrate 3. Estimation of iodine value of a given oil/fat 4. Estimation of ascorbic acid in fruit juice 5. Separation of a mixture of amino acid 6. Extraction of natural product						
Referenc e material	1. Instruction manual provided by the Instructor 2. Vogel's Textbook of practical organic chemistry 3. An Advanced Curse in Practical Chemistry: Nad, Mahapatra and Ghoshal						

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	1		2	2	1	2	1
CO2	3	2	3	3	1	2		2	3	1	2	1
CO3	3	1	3	3	1	1		2	3	1	3	1
CO4	1	1	2	3	1	1		2	2	1	2	1

FIFTH SEMESTER

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR)

/
Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture(L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC501</td><td>Fundamentals of Electrochemistry and surface chemistry</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment)
(EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">• CO1: Application of conductometric measurement.
• CO2: Understanding the dissociation of electrolytes in solution and its application..
• CO3: Electro-chemcial cell: principle and application.
• CO4: Understanding the adsorption process.
• CO5: Fundamentals and application of micellar and colloid system.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Conductance:
Electrolytic conduction, velocity of ions: specific, equivalent and molar conductances, Kohlrausch’s law, strong and weak electrolytes, transport number, its determination, abnormal transport number, conductometric titrations, Applications of conductance measurement. 6L
Ionic equilibrium:
Concept of pH, pH of acids and bases, hydrolysis of salts, buffer solutions, pH metric titration, activity and solubility product: common ion and salt effect. 4L
Electrochemical cells:
Different types and evaluation of cell potential, various factors affecting the potential, determination of thermodynamic parameters, potentiometric titration, application of EMF measurement, Concentration cell, liquid junction potential, commercial cells including fuel cell, Li ion battery, dye sensitized solar cell. 12L
Adsorption:
Langmuir, BET, Gibbs adsorption isotherms, surface tension and surface pressure, contact angle: interfacial tension, Hysteresis. 6L</td></tr>
</table>

	Micellar system: Concept of micelle, reverse micelle and microemulsion, hydrophobic effect, factors affecting CMC, determination of CMC, Thermodynamics of micellisation, micellar aggregation number and fraction of counter ions bound to a micelle. 8L **Colloidal system:** Theory of electrical double layer, zeta potential. Colloids: classification of colloidal systems, stability of colloids, their properties and applications. 6L
TextBooks,	1. Physical chemistry by P. Atkins and J.de Paula 2. Physical chemistry by Laidler and Meiser 3. A text book of physical chemistry by K.L.Kapoor 4. Physical chemistry by P.C.Rakshit 5. Introduction to applied colloid and surface chemistry by G. M. Montogeorgis and S. Kill (Wiley) 6. Physical Chemistry of surfaces by A. W. Adamson and A. P. Gast (Wiley India)

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	1	1	1	2	1	1	1	1
CO2	3	1	1	3	1	1	1	2	1	2	1	1
CO3	3	1	3	3	2	3	1	3	3	3	2	2
CO4	3	1	1	1	1	1	1	2	2	1	1	2
CO5	3	1	3	2	2	2	1	3	3	3	2	2

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC502	**Chemistry in Solution and Solid State Chemistry**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Course Outcomes	• CO1: understand different concepts of acids and bases • CO2: know about the thermodynamic aspects of Lewis acid and base interaction • CO3: understand the concept of redox reaction, standard redox potential • CO4: have concept of effect of concentration and pH on redox reaction • CO5: know basic idea of Inorganic solid and crystal • CO6: know the thermodynamics and energetics of stability of solid • CO7: Born Lande equation and Kapustinskii equation, • CO8: crystal system and different types of unit cells and crystals in inorganic solid • CO9: defect of crystal and the associated property	
Topics Covered	**Concept of acids and bases:** The Arrhenius concept, Concept of K_w, , concept of pH, Strength of aicds and bases(hydracids and oxyacids), levelling effect of water , solvent concepts, Bronsted Lowry concept, Lewis concepts	05
	Hard-Soft acid base concept, relation of hardness to ionisation potential and electronegativity and frontier orbital	02
	Thermodynamic of Lewis acid and base interaction, the Drago-Wayland equation	01
	Monoatomic ions and their acid –base properties, polyatomic ions and their acid-base properties	01
	Redox Chemistry:	
	Redox reaction, ion electron balancing, standard reduction potential and their diagrammatic representation	03
	Redox predominance diagrams of elements, disproportionation and metastable state	02
	Redox chemistry and extraction of elements from ores. Ellingham diagrams	02
	Effect of concentration and pH on redox reaction, uses of redox series in chemical reaction, Pourbaix diagrams	03
	Ionic equilibrium and precipitation reactions:	01
	Ionic compounds: Factors effecting ionic radii, Fajans rule, lattice energy, Born Haber cycle and its application	04
	Born Lande equation, modification of Born-Lande equation, Kapustinskii equation, radius ratio rule	04
	Solid State Chemistry:	
	Crystal system and lattices, unit cell, Miller planes, crystal packing, metallic bond	04
	ionic crystals, structures of AX, AX_2, AX_3, A_2X_3, type Structures of mixed metal oxides: spinel and inverse spinel, perovskite	04
	Crystal structure related to super conductivity, ferroelectric and piezo electric property, crystal defects, stoichiometric and nonstoichiometric defect, Schottkey and Frenkel defect, etc.	04
	Inorganic nanomaterial and polymers.	

Text Books, and/or reference material	Suggested Text Books: 1) Inorganic Chemistry, Part I ,R.L. Dutta New Book Stall 2) Fundamental concept of Inorganic Chemistry, vol 3, Asim K. Das, CBS publishers & distributors 3) Inorganic Chemistry, Huheey, Keiter, Keiter, Medhi, Pearson education 4) Inorganic chemistry, Shriver & Atkins, Oxford 5) Concept and models of inorganic Chemistry, Douglas, Mcdeniel, Alexander, Wiley indiaPvt. Ltd. 6) Concise inorganic chemistry, Lee, Wiley india Pvt. Ltd.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	--	1	1	3	2	1	2	1
CO2	3	3	3	3	--	1	1	3	2	1	2	1
CO3	3	3	3	3	--	1	1	3	2	1	2	1
CO4	3	3	3	3	--	1	1	3	2	1	2	1
CO5	3	2	3	3	--	1	1	3	2	1	2	1
CO6	3	3	3	3	--	1	1	3	2	1	2	1
CO7	3	3	3	3	--	1	1	3	2	1	2	1
CO8	3	3	2	2	--	1	1	3	1	1	2	1
CO9	3	3	3	3	--	1	1	3	2	1	2	1

Department of Chemistry								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 503	**Chemistry of Heterocyclic Compounds and Natural Products**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	• CO1: Nomenclature, aromaticity acidity-basicity of heterocyclic compounds • CO2: Synthesis and reactions of heterocyclic compounds • CO3: Study of heterocycles with two or more hetero atoms including purine & pyrimidine • CO4: Classification, general reactions of alkaloids aiding their isolation, purification and structure determination • CO5: Structure determination, synthesis and reactions of simple alkaloids
Topics Covered	Nomenclature of heterocycles, common nomenclature, replacement method, Hantzsch-Widman (IUPAC or Systematic) method (3 Lec) Aromatic and nonaromatic heterocycles, molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine and other small ring heterocycles. Comparison of basicity of pyridine, piperidine and pyrrole (3 Lec) Generalized approach to the synthesis of heterocycles possessing 5, 6 and 7 membered rings with one or two heteroatoms (3 Lec) Reactions of heterocycles: with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. Oxidation and reduction. (8 Lec) Fused five and six – membered heterocycles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler- Napieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline (4 Lec) Five and six membered heterocycles with two or more hetero atoms (4 Lec) Purine & pyrimidines: Structure, synthesis, reactions (4 Lec) Alkaloids: Classification; general reactions of alkaloids; chemistry of simple alkaloids like chavicine, piperine, nicotine, quinzoline ring. (14 Lec)
Text Books, and/or reference material	Suggested Text Books: 1. Organic Chemistry, Volume 2: Stereochemistry and the Chemistry Natural Products, I. L. Finar, Pearson Education India, 2002. 2. Heterocyclic Chemistry, T. R. Gilchrist, Longman, 1989. 3. Topics in Heterocycles Chemistry. G. W. Gribble. Spinger-Verlag Berlin Heidelberg, 2010. Suggested Reference Books: 4. Modern Heterocyclic Chemistry. 4 Volume Set. Julio Alvarez-Builla, Juan Jose Vaquero, José Barluenga. Wiley. 2011. 5. Principles of Modern Heterocyclic Chemistry, L.A. Paquette, W.B. Benjamin, Inc., 1978. 6. Handbook of Heterocyclic Chemistry. Alan R. Katritzky and A. F. Pozharskii, Elsevier, 2000. 7. The Chemistry of Heterocycles. T. Eicher, S. Hauptmann, Wiley-VCH 2003 8. Heterocyclic Chemistry, J.A.J. Joule and G.F. Smith, ELBS, 2nd Ed., 1982.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	2	3	1	3	3	3	2	3
CO2	3	3	3	3	3	3	2	3	3	3	2	3
CO3	3	3	3	3	3	3	1	3	3	3	2	3
CO4	3	3	3	3	3	3	1	3	3	3	3	3
CO5	3	3	3	3	3	3	1	3	3	3	3	3

<table>
<tr><td colspan="8">Department of Chemistry</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC504</td><td>Industrial Chemistry</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understanding the applications of chemistry in the industrial set-up
• CO2: Development of basic knowledge of industrial application
• CO3: Learning of different chemical tools which are useful and valued in industry
• CO4: Generation of knowledge to bridge the gap between education and industrial application so the students might be confident to apply for industrial career. .</td></tr>
<tr><td rowspan="6">Topics Covered</td><td colspan="6">1 Fuel: Coal, Petroleum, Gaseous fuels and Biofuels (including industrial process for liquefaction of coal, distillation of petroleum, analysis of coal)</td><td>10</td></tr>
<tr><td colspan="6">2. Glass and ceramics: Different types of glass and ceramics, and their chemical compositions, reactions, chemical properties</td><td>4</td></tr>
<tr><td colspan="6">3. Cement: Types, different types industrial preparations, composition and chemistry</td><td>3</td></tr>
<tr><td colspan="6">4. Rubber and Plastic: Polymer Chemistry, introduction, types, structure, synthesis, natural rubber, vulcanization, thermosetiing plastics, industrial polymers and their chemistry</td><td>5</td></tr>
<tr><td colspan="6">5. Paints and pigments: Introduction, definitions, types, emulsions, additives, anti-corrosion properties, chemical formulas and compositions</td><td>5</td></tr>
<tr><td colspan="6">6. Biotechnology Industry: Introduction, Bioremediation of chemical waste, Bioleaching of ores, Biocatalyst, Fermentation, production of vinegar, Biofuel.</td><td>7</td></tr>
</table>

Text Books, and/or reference material	1. Industrial inorganic Chemistry by KH Büchel, HH Moretto, P. Woditsch 2. Industrial Chemistry by B K Sharma 3. Biotechnology in the Chemical Industry: Towards a Green and Sustainable Future by P Bazpai

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	3	1	3	3	3	2	3
CO2	3	3	3	3	3	3	2	3	3	3	2	3
CO3	3	3	3	3	3	3	1	3	3	3	2	3
CO4	3	3	3	3	3	3	1	3	3	3	3	3

CYS551	**Chemical Kinetics, Surface Chemistry and Conductometry Laboratory**	PCR (Practical)	**L** 0	**T** 0	**P** 3	**H** 3	**C** 1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA)and Viva-Voce)					
NIL		CT + Viva-voce					
Course Outcome (The students will well-acquainted with)	• CO1: Monitoring kinetics of reactions by various experimental methods. • CO2: Evaluation of adsorption isotherm. • CO3: Knowledge of conductometric estimation. • CO4: development of laboratory skill, data handling and interpretation, error analysis.						
Topics Covered	1. Determination of rate constant of inversion of sucrose 2. Determination of rate constant of hydrolysis of ester by conductometry 3. Study of the kinetics of the reaction between $K_2S_2O_8$ and KI, determination of rate constant and influence of ionic strength on it 4. Kinetic study of Iodine clock reaction 5. Determination of amount of acetic acid adsorbed by charcoal and evaluation of adsorption isotherm 6. Conductometric determination of strength of acid in a mixture 7. Verification of Ostwald dilution law 8. Measurement of interfacial tension by Contact angle measurement Any other practical as assigned by the Instructor						

Reference material	1. Instruction manual provided by the Instructor 2. Selected experiments in Physical Chemistry By N.G.Mukherjee 3. Advanced Physical Chemistry Experiments: By Gurtu & Gurtu

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	1	1		2	1	1	2	1
CO2	3	1	1	3	1	1		2	1	1	2	1
CO3	3	1	1	3	1	1		2	1	1	3	1
CO4	1	1	1	3	1	1		2	2	1	2	1

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR)/ Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYS552</td><td>Quantitative Estimation of Metal ions in Mixture</td><td>PCR (Practical)</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA) along with Viva-Voce)</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT and Viva voce</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">• CO1: Basic concepts of quantitative estimation
• CO2: Understand to evaluate the estimation of ion mixture
• CO3: Understand the fundamental, scientific basis, preparation of sample, sampling method and analytical methods.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Permanganometry: Fe(III) and Mn(II) in a mixture.
2. Dichromatometry: Fe(III) and Cu(II) in a mixture; Fe(III) and Cr(III) in a mixture.
3. Complexometry: $CaCO_3$ and $MgCO_3$ in mixture; Mg(II) and Zn(II) in mixture using EDTA; Complexometric estimation of sulphate and phosphate ion;
4. Analysis of four components mixture (Al^{+3}, Fe^{+3}, Co^{+2}, Ni^{+2}).
5. Gravimetric estimation of $Ni(DMG)_2$;
Some more experiments as decided by the Instructor.</td></tr>
</table>

Text Books, and/or reference material	1. An Advanced Course in Practical Chemistry by Nad, Ghosal and Mohapatra, New Central Book agency. 2. A Manual of Practical Chemistry for Degree Classes (Vol I & II) by R. C. Bhattacharya, 3. College Practical chemistry by Ahluwalia, Dingra and Gulati. 4. Vogels textbook of quantitative chemical analysis By J Mendham, R. C. Denney, M. Thomas and D. J. Barnes, Pearson India. 5. APHA, A, WEF, (1998). Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works Association,Water Pollution Control Federation, Washington DC.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	1	2	--	2	3	2	3	1
CO2	3	3	2	3	1	2	--	1	3	2	3	1
CO3	3	3	2	3	--	2	1	2	3	2	3	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS553	**Quantitative analysis of organic samples**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods: Continuous assessment and Viva-Voce at the end of the semester.					
None		CT+VIVA					
Course Outcomes	• CO1: A basic idea about the methodology of quantitative analysis of organic compounds. • CO2: Concept about the uses of reagents and solvents for quantitative analysis of organic compounds • CO3: The uses of these quantitative analysis for important compounds.						
Topics Covered	1. Estimation of $-OCH_3$ group by Zeisel's method 2. Estimation of carbonyl group 3. Estimation of acetyl group 4. Estimation of amine group (van Slyke method) 5. Estimation of nitrogen by Kjeldahl method 6. Estimation of phosphorus 7. FAME analysis by GC/ GC-MS 8. Analysis of monosaccharide composition by HPLC 9. Quantitative estimation of C, H, N and S present in organic sample by CHNS analyzer.						

Text Books, and/or reference material	(i) Textbook of Practical Organic Chemistry by Vogel **(ii)** Comprehensive Practical Organic Chemistry: Quantitative Analysis by Ahluwalia

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	2	2	2	3	2	3	1
CO2	2	2	3	3	2	2	3	2	3	1	2	2
CO3	3	3	3	2	1	3	2	3	2	2	1	1

SIXTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC601	**Basics of photochemistry, Spectroscopy, group theory and data analysis**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment) (EA))
NIL	CT+EA

Course Outcome	• CO1: Physical understanding of photochemistry and photo-physical processes. • CO2: Fundamentals of different molecular spectroscopy. • CO3: Introduction to symmetry and concept of point group. • CO4: Application of spectroscopy and symmetry to unravel the molecular structure. • CO5: Concept of data analysis and its applications.
Topics Covered	**Photochemistry:** Lambert-Beer's law and its application, Basics of photochemical reactions, primary processes, reactions of electronically excited species; law of photochemical equivalence, Franck-Condon principle, fluorescence and phosphorescence, Jablonsky diagram, Non-radiative processes,Concept of excited state life-time. Laws of photochemistry, quantum yield, kinetics of HI decomposition, H_2-Br_2 reactions, quenching, basic techniques of absorption and emission spectroscopy. 10L **Basics of spectroscopy:** Elementary idea of rotational, vibrational and electronic spectroscopy. 10L **Symmetry:** Introduction of symmetry and point groups, symmetry operations. Reducible and Irreducible representation and character table.10L **Data Analysis:** Statistical data analysis, mean, median, mode, frequency, standard deviations, mean deviation, etc. Frequency analysis, Normal distribution, Poisson distribution and others. Regression analysis, correlation. 12L
TextBooks,	1. Modern molecular photochemistry by N. J. Turro 2. Fundamentals of molecular spectroscopy by Banwell 3. Fundamentals of photochemistry by Rohatgi-Mukherjee 4. Statistical methods, vol 1 and 2 by N. G. Das 5. Group theory and chemistry by Bishop

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	3	1	1	1	1
CO2	3	3	1	2	1	1	1	3	1	2	2	2
CO3	3	3	1	2	1	1	1	3	3	1	1	2
CO4	3	3	2	2	1	3	1	3	3	3	3	2
CO5	3	1	1	3	1	1	1	3	3	2	2	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC602	**Coordination Chemistry**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcome (Students will be enriched by)	• CO1: Concepts of coordination complexes, ligand types and isomerism • CO2: Theories of bonding (e.g. VBT, CFT, MOT) • CO3: Application of CFT and MOT to explain the spectroscopic and magnetic properties of metal-ligand complexes. • CO4 : Spectroscopic Term symbols, Orgel diagram and Tanabe Sugano diagram • CO5 : Circular dichroism, optical rotatory dispersion, cotton effect • CO6 : Electronic spectral properties of Lanthanides and actinides
Topics Covered	Bloomstantrand-Jorgensen's chain theory, Warner's theory of coordination compounds , double salts and complex salts, perfect and imperfect complexes, detection and evidence of complex formation in solution. 4L Classification of Ligands, Inner-metallic complex, Poly nuclear or bridged complexes, Nomenclature of coordination compounds 4L Structure, isomerism and stereochemistry, structural isomerism, conformational isomerism, stereoisomerism, geometric isomerism, optical isomerism 4L Theories of bonding : Valence bond theory, crystal field theory, Factor effecting the crystal field splitting parameter, Pairing energy and controlling the pairing energy, CFT and octahedral complexes, CFT and tetrahedral complexes, CFT and TPB and square pyramidal complexes, Tetragonal distortion, in octahedral symmetry , Jahn Teller distortion, CFT and square planer complex, Application of CFT. 8L

	Molecular orbital Theory of Octahedral, tetrahedral and square planer complexes, spectrochemical series and nephelauxeic series 4L Electronic spectra of transition metal complexes: Type of electronic spectra, selection rules, Relaxation of selection rule, band intensity , band width, symmetric and asymmetric bands. 3L Spectroscopic term symbols , Orgel diagram, examples, limitation of orgel diagram. 5L Tanabe Sagano diagram, Charge Transfer spectra, Intervalence electron transfer bands. 3L Circular dichroism, optical rotatory dispersion, cotton effect. 3L Electronic spectra of lanthanide and actinide complexes. 2L
Text Books, and/or reference material	1) Inorganic Chemistry, Part I ,R.L. Dutta, New Book Stall 2) Fundamental concept of Inorganic Chemistry, vol 4 & 5, Asim K. Das, CBS publishers & distributors 3) Inorganic Chemistry, Huheey, Kieter, kieter, Medhi, Pearson education 4) Inorganic chemistry, Shriver & Atkins, Oxford 5) Concept and models of inorganic Chemistry, Douglas, Mcdeniel, Alexander, Wiley indiaPvt. Ltd. 6) Concise inorganic chemistry, Lee, Wiley indiaPvt. Ltd. 7) Inorganic Chemistry by Housecroft and Sharp. 8) Principles of Inorganic Chemistry by B. W. Pfennig

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	1	2	3	3	2	1	1
CO2	2	2	3	2	2	2	2	3	3	1	1	1
CO3	2	3	3	2	2	3	2	3	3	3	1	1
CO4	2	2	3	2	2	3	2	3	3	2	1	1
CO5	3	2	3	2	2	3	2	3	3	3	1	1
CO6	3	2	3	2	2	3	2	3	3	3	1	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC603	**Reagents in Organic synthesis**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	• CO1: A basic idea on synthesis of organic compounds has been incorporated using some specific reagents for particular compound synthesis. • CO2: How the better yield could be obtained, their strategy has been highlighted. • CO3: Role of specific reagents and catalysts including mechanism in their transformation from substrate to products is included for their step by step synthesis.
Topics Covered	1. Some important reactions with reagents: Aromatic electrophylic (Friedel craft reaction) and nucleophilic substitution reactions, Cine substitution reactions, Aldol and Michael condensation reactions, Robinson annulation reaction; Synthesis of bio-molecules like steriod Oestrone-1, ± Zearalenone and Isonotkatone via Retro synthesis. 9L 2. Protection and deprotection of functional groups; Merrifield reagents (protection and deprotection of amino group in solid state peptide synthesis; Ring expansion and ring contraction reactions; Regio-selective and enantio-selective reactions controlled by special reagents, Assymmetric synthesis by Oxazoline derivatives, bis-lactone ether based chiral auxiliary. 9L 3. Special reagents and reactions: Barton reaction, Wittig reaction; Peterson's synthesis (olifination); 2,3-dichloro-5,6-dicyano-1,4 benzoquinone (DDQ); Umpolung reactivity (1,3-Dithianes); Dicyclohexyl-carbodiimide (DCC); OsO_4; Woodward and Prevost hydroxylation; SeO_2; Phase transfer catalyst, purple benzene, cryptates and clathro chelates; Wilkinson catalyst; hydroformylation reactions or Oxo reactions; Sapiro reaction; Favoriski reactions; Hoffmann-Löffler reaction; Baker's yeast (enzymatic reduction) and Gilman reagents. 9L 4. Special reagents used in oxidation and reduction organic transformation reactions: Oxidation reaction: CrO_3, pyridine complex, Mn(IV) oxide (used in retinal synthesis), RuO_4, Sharpless epoxidation, Moffat oxidation, Swern oxidation, Dess-Martin periodinane oxidation. Reduction reaction: hydride transfer reagents: DIBAL; Na(CN)BH; Trialkylborohydrides; trialkyltin hydride; Low valent titanium(II) oxide, diimide. 9L
Text Books, and/or reference material	**Suggested Text Books: (i) Modern Methods of Organic Synthesis 4th Edition, W. Carruthers Cambridge University Press** (ii) Reaction Mechanism in Organic Chemistry: S.M. Mukherji and S. P. Sinha; Macmillan India Pvt Ltd. (iii) Organic synthesis Through Disconnection Approach: P. S. Kalsi; (iv) Modern synthetic reactions by H. O. House. (v) Principles of Organic synthesis: R.O.C. Norman and J.M. Coxon; CRC Press

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	2	2	3	3	2	3	2
CO2	2	3	3	3	2	2	3	2	3	3	2	2
CO3	3	3	3	2	1	3	2	3	2	2	1	2

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	ECONOMICS AND MANAGEMENT ACCOUNTANCY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• To review basic economic principles with students; • To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works; • To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.
Topics Covered	PART 1: Economics Group A: Microeconomics Unit 1: Economics: Basic Concepts Unit 2: Theory of Consumer Behaviour Unit 3: Theory of Production, Cost and Firms Unit 4: Analyses of Market Structures: Perfect Competition Unit 5: Monopoly Market Unit 6: General Equilibrium &Welfare Economics Group B: Macroeconomics Sl. No. Name Unit 1: Introduction to Macroeconomic Theory Unit 2: National Income Accounting Unit 3: Determination of Equilibrium Level of Income Unit 4: Money, Interest and Income Unit 5: Inflation and Unemployment Unit 6: Output, Price and Employment PART 2: Accountancy Sl. No. Name Unit 1: Introduction to Accounting Unit 2: Primary Books of Accounts (Journal) Unit 3: Secondary Books of Accounts (Ledger) Unit 4: Cash Book Unit 5: Bank Reconciliation Statement Unit 6: Trial Balance Unit 7: Final Accounts

Text Books, and/or reference material	Suggested Text Books: PART 1: Economics Group A: Microeconomics 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. Anindya Sen: Microeconomics: Theory and Applications 4. Pindyck & Rubenfeld: Microeconomics Group B: Microeconomics 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. Soumyen Sikder: Principles of Macroeconomics PART 2: Accountancy 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	1	-	-	3	-	-	3	2	1	-
CO2	3	2	-	1	-	2	-	2	-	-	3	1
CO3	-	-	-	-	1	-	3	-	-	-	2	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE611	**Analytical and Environmental Chemistry**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NIL		CT+EA					
Course Outcome (Students will be enriched by)	• CO1: Knowledge on chemical processes that regulate the environment as well as attention will be paid to understanding chemical equilibrium and kinetics of natural systems. • CO2: The course is designed to give the students a broad understanding of the issues related to the basic concepts and principle of different analytical techniques.						

	• CO3: This course imparting the knowledge about the theory and techniques of analysis including introductory instrumental methods and its fundamental principle. • CO4: Knowledge on quantification of various environmental parameters. • CO5: Knowledge on Ecologically safe alternatives and basic principle of green chemistry.
Topics Covered	**Analytical chemistry**: Quantitative and qualitative analysis: Detection of element, detection of cations and anions, Volumetric analysis (acid-base, redox, complexometric), Colorimetric analysis, Titrimetric analysis, gravimetric analysis, conductometric, poteiometric titration , ion selective electrodes etc. 18 **Environmental chemistry:** Chemical aspects of air, water and soil pollution, chemistry of photochemical and sulphurous smog, stratosphere-chemistry and pollution, chemical specification, priority and water pollutants-their effects, chemical analysis and control. Radioactive and Biomedical waste disposal. Ecological balance and planning of Industrial complexes. Application of Bioreactors in industries for pollution control. Ecologically safe alternatives and basic principle of. Green chemistry. 18 lec
Text Books, and/or reference material	1. Skoog and West's, Fundamentals of Analytical Chemistry, Cengage Learning India Pvt. Ltd., Delhi 2. Sawyer, C.N., McCarty, P.L., and Parkin, G.F., Chemistry for Environmental Engineering, 5th Edition, McGraw-Hill, Inc., New York. 3. Manahan, S.E., Fundamentals of Environmental Chemistry, Lewis Publishers, Inc., Boca Raton. 4. Seinfeld, J. H. and Pandis, S N., Atmospheric Chemistry and Physics : from Air Pollution to Climate Change, John Wiley. 5. Weber, W. J. Jr., Physicochemical Processes for Water Quality Control, John Wiley and Sons Inc., New York. 6. A. K. Dey, *Environmental Chemistry*, Wiley Eastern, 2002. 7. A. S. Douglas, F. J Holler, S. R. Crouch, Principles of Instrumental Analysis, Thomson, 2007. 8. Metcalf& Eddy, Wastewater Engineering-Treatment and Reuse., 4th edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/MathISBN-13: 978-0070418783, ISBN-10: 0070418780

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	2	2	3	3	2	1	1
CO2	2	2	3	2	2	2	2	3	3	1	1	1
CO3	2	3	3	2	2	2	2	3	3	3	1	1
CO4	3	3	3	1	2	2	3	3	3	3	1	1
CO5	3	3	3	1	1	3	3	3	3	2	1	1

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Titleof the course</td><td rowspan="2">Program Core (PCR)/ Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYE612</td><td>Chromatographic Separation and Instrumental Methods of Analysis</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA)</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">• CO1: Get a comprehensive knowledge about solvent extraction, ion exchange and different chromatographic techniques
• CO2:Application of these techniques in practical and industrial capacity
• CO3:Working principles and application of some instrumental methods</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Separation techniques:
Solvent extraction, distribution law, distribution constant, extraction of inorganic species, separation of metal ion as chelates, extraction of metal chlorides and nitrates, solid phase extraction
Ion exchange, ion exchange resin, ion exchange equilibria, application of ion exchange methods, home water softeners
Chromatography: general description of chromatography, classification of chromatography, elution of column chromatography, migration rates, distribution constants, relation between, volumetric flow rate and linear flow rates, retention factor, selectivity factor, rate theory of chromatography, a quantitative description of column efficiency, thin layer chromatography (TLC)
Gas chromatography (GC), Instrumentation, Introduction, carrier gas system, sample injection system, column configurations and column oven, detection system, characteristic of ideal detector, FID, TCD, ECD, mass spectroscopy gas chromatography column and stationary phase, capillary, tubular column, packed column, liquid stationary phase, applications
High performance liquid chromatography: partition or liquid liquid chromatography, adsorption or solid liquid chromatography, ion exchange or ion chromatography, size exclusion chromatography, and chiral chromatography
Instrumental method:
Thermoanalytical Techniques: thermogravimetric analysis (TGA), Introduction, principle, instrumentation, Factors affecting TGA, application, differential thermal analysis, principle, instrumentation, application</td></tr>
</table>

	Electroanalyticaltechniques:electrogravimetry,electricalcomponents,Galvanostat and potentiostat, principle, experiments, coulometry, principle, colulometer, coulometry cell, constant current coulometry Polarography: Principal, process of current, polarogrphic cell, Ilkovic equation, half wave potential, experimental set up, application, quantitative and qualitative analysis, c y c l i c voltammetry: principal, cellconfiguration, instrumentation and circuit, application Atomic absorption spectroscopy: Principle, Instrumentation, application 02
Text Books, and/or reference material	1. Fundamentals of analytical chemistry, Skoog, West, Hollerand Crouch,8th edition, Thomson 2. Instrumental methods of analysis, Williard, Merit, Dean, Settle, CBS publishers &distributors 3. Inorganic electrochemistry, Theory practice and application, Piero Zanzello, RS.C

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	3	3	3	3	2
CO2	3	3	3	3	3	3	3	3	3	2	1	2
CO3	3	3	3	3	3	3	3	3	3	3	3	2

CYS651	**Potentiometric and Colorimetric Analysis**	PCR (Practical)	**L** 0	**T** 0	**P** 3	**H** 3	**C** 1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA)and Viva-Voce)					
NIL		CT + Viva-voce					
Course Outcome (The students will well-acquainted with)	• CO1: Handling spectrophotometer and knowledge on its application. • CO2: Construction of electrochemical cell and measuring cell potential. • CO3: Application of potentiometric estimation. • CO4: development of laboratory skill, data handling and interpretation ,error analysis.						

Topics Covered	1. Verification of Beer's law 2. Determination of E^0 of quin-hydrone electrode 3. Determination of phosphate concentration in a soft drink 4. Estimation of dissociation constant of acetic acid potentiometrically 5. Titration of Mohr's salt solution and determination of formal potential of Fe3+/Fe2+ system 6. Determination of Solubility product of silver chloride potentiometrically Any other practical as assigned by the Instructor
Reference material	1. Instruction manual provided by the Instructor 2. Selected experiments in Physical Chemistry By N.G.Mukherjee 3. Advanced Physical Chemistry Experiments: By Gurtu & Gurtu

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	1	2		2	1	2	2	1
CO2	3	1	1	3	1	2		2	1	2	2	1
CO3	3	1	1	3	1	2		2	1	2	3	1
CO4	1	1	1	3	1	1		2	2	1	2	1

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS652	**Analysis of Ores and Alloys**	PCR (Practical)	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA) along with Viva-Voce)					
NIL		CT and Viva voce					
Course Outcome (The students will master the following)	• CO1: Basic concepts of Ores and alloys • CO2: Understand to evaluate the analysis of different ores and alloys • CO3: Understand the fundamental, scientific basis, preparation of sample, sampling method and analytical methods.						
Topics Covered	Analysis of a) high speed steel; b) dolomite; c) brass; d) bronze; e) bauxite; f) pyrolusite;						

Text Books, and/or reference material	1. An Advanced Course in Practical Chemistry by Nad, Ghosal and Mohapatra, New Central Book agency. 2. A Manual of Practical Chemistry for Degree Classes (Vol I & II) by R. C. Bhattacharya, 3. College Practical chemistry by Ahluwalia, Dingra and Gulati. 4. Vogels textbook of quantitative chemical analysis By J Mendham, R. C. Denney, M. Thomas and D. J. Barnes, Pearson India.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	1	2	--	2	3	2	3	1
CO2	3	3	2	3	1	2	--	1	3	2	3	2
CO3	3	3	2	3	--	2	1	2	3	2	3	2

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS653	**Single Step Synthesis of Organic Compounds**	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA) and Viva-Voce)					
None		CT AND Viva-Voce					
Course Outcomes	• CO1: To reach a targeted product through singlestep reaction process using suitable reagents and optimum reaction conditions. • CO2: To learn Separation and Purification of products • CO3: To learn Purification techniques, like phase transfer, crystallization, GC-Mass and other spectroscopic method will be adopted • CO4: To Learn Understand the basic concept behind separation process for most common spectroscopic method like; UV-Vis, FT-IR, NMR, ESI-Mass and GC-Mass. • CO5: To learn how to reach a maximum yield with minimum uses of solvent, reagents and energy like; heat and electricity (Green chemistry).						
Topics Covered	1. Synthesis of Osazone 2. Preparation of triphenyl methanol 3. Synthesis of *tans*-p-anisalacetophenane (aldol) 4. Oxidation of 4-chlorobenzyl alcohol to 4-chlorobenzoic acid 5. Nitration of bromobenzene (aromatic substitution) 6. Preparation of 2-chloro-2-methyl butane from 2-methyl-2-butanol (substitution) 7. Reaction of 1,3-cyclopentadiene with maleic anhydride (Diels-Alder reaction)						

Text Books, and/or reference material	1. Vogel's Textbook of practical organic chemistry 2. Advanced practical chemistry : Subas C. Das 3. An Advanced Curse in Practical Chemistry: Nad, Mahapatra and Ghoshal

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	3	3	1	2	3	2	1	2
CO2	3	3	3	2	2	3	1	3	2	2	1	2
CO3	3	2	3	2	2	2	2	3	2	2	1	1
CO4	3	3	3	2	2	3	3	3	2	3	2	2
CO5	3	3	3	3	2	3	3	3	2	3	1	2

SEVENTH SEMESTER

<table>
<tr><td colspan="9">Department of Management Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MSC731</td><td>PRINCIPLES OF MANAGEMENT</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1:To make budding engineers aware of various management functions required for any organization
• CO2:To impart knowledge on various tools and techniques applied by the executives of an organization
• CO3:To make potential engineers aware of managerial function so that it would help for their professional career
• CO4:To impart knowledge on organizational activities operational and strategic both in nature
• C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT I: Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter’s five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization(8)
UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7)
UNIT III: Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8)
UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8)
UNIT V: Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books</u>:
1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House.
2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India
3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education</td></tr>
</table>

	4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 5. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs **COs**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	2	2	
CO2				2					2	2		
CO3				2					3	2		
CO4							1		3			
CO5				2					2	2	2	

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC701	**Quantum Chemistry and Spectroscopy**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA))					
NIL		CT+MT+EA					
Course Outcome (The students will master the following)	• CO1: Foundationinquantummechanicstoremindthedifferencebetweenmacroscopic (classical) and microscopic (quantum) world. • CO2: Understandtheconceptofquantizationofenergyandwave-particleduality • CO3: Solving Schrödinger wave equation for model quantum systems. • CO4: Understand the bases behind interaction of light and matter and account for most common spectroscopic methods. • CO5:Analyzingmicroscopicintramolecularinteractionsandpropertiesof molecules						

Topics Covered	Fundamentals of quantum mechanics: operators, functions, basic postulates 5 LecTime-independentSchrödingerequation,freeparticle,particleinaboxofvariousdimensions, 3 Lec Tunnelling effect 2Lec Rigid rotation in a plane 2Lec Rotation of diatomic molecule, spherical harmonic functions 3LecH armonicoscillator 2 Lec Electronicwavefunctionofhydrogenandhydrogen likeatom 3Lec Magneticeffecton electronmovement 2Lec Raisingand loweringoperators 2Lec Manyelectrontheory,Slaterdeterminant, Pauliexclusionprinciple 2Lec Time-dependentSchrödingerequation 2 Lec Atomicandmoleculartermsymbol 2 Lec Atomicspectra 2 Lec Pure rotational and vibrational spectra of diatomic and polyatomic molecules 3 L Vibrational-rotationalcoupling 2Lec Raman spectroscopyofmolecules,concept of molecularpolarizability 4Lec Electronicspectraofmolecules 2Lec
TextBooks, and/or reference material	1.Quantum ChemistrybyLevine 2.PhysicalChemistry:AMolecularapproachbyDonaldA.McQuarrie 3.IntroductoryquantumchemistrybyA. K.Chandra 4.Chemicalapplications ofGroup theorybyF. A. Cotton 5.MolecularQuantum MechanicsByAtkinsandFriedman,Oxford 6.Fundamentalsof molecularspectroscopyByBarnwell and McCash.

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	3	3	2	2	1	1
CO2	3	2	3	2	2	2	3	3	2	2	1	1
CO3	3	2	3	2	2	2	3	3	2	2	1	1
CO4	3	3	3	2	2	3	3	3	2	3	1	1
CO5	3	3	3	2	2	3	3	3	2	3	1	1

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC702</td><td>Inorganic reaction mechanisms and magnetochemistry</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">
CO1: Basic concept of inorganic reaction mechanism associated with octahedral and square planar complexes.
CO2: Types of electron transfer reactions of the complexes including the detail mechanism
CO3: Solving the problems related to Marcus theory.
CO4: Types of magnetic substances and their magnetic properties.
CO5: Quantum numbers and origin of magnetic moments; microstates and derivation of Russel-Saunders Terms for various electronic configuration, Lande Interval Rule, Hole formalism and equivalency.
CO6: Determination methods of magnetic susceptibility of various metal complexes, multiplet widths and derivation of various equations to determine magnetic moments, orbital magnetic moment quenching, concept of high-, low-, intermediate- and admixed-spin state and their interactions.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">(i) Stoichiometric mechanism, second order limiting rate constant, base hydrolysis, Effects of non-leaving ligands, proton exchange, activation parameters 5Lec
(ii) Stereochemistry of octahedral substitution reactions, racemisation reaction (Bailar twist and Ray –Dutt twist) 4Lec
(iii) Square planar complexes: Ligands substitution reactions, General features, significance of rate law, effect of entering and leaving ligands, The trans effect, theories of trans effect, grounds state effects, transition effect, steric effects of non-leaving ligands, catalysis of substitution by redox process. 4Lec
(iv) Electron transfer reaction: Types of electron transfer reaction, outer sphere electron transfer process: electron transfer and reorganisation and chemical activation, potential energy diagram, Marcus theory for outer sphere cross reaction. 5Lec
(v) Inner sphere electron transfer process: steps, rate law, types of inner sphere electron transfer process, bridging ligand, remote attack, the chemical mechanism. 4Lec
vi) Definition of magnetic properties, types of magnetic bodies, sources of paramagnetism: orbital and spin effects, Diamagnetism and Pascal’s constant, diamagnetic correction of ligands and metal complexes 3Lec
(vii) Quantum numbers and vectors, Mutual inclination of electron orbits and resultant vectors, Russel-Saunders coupling and j-j coupling, Ground State Term Symbol and Hund’s rules 2Lec</td></tr>
</table>

	(viii) Microstates and derivation of Russel-Saunders Terms for p^2, d^2 and pd configuration, Spin-orbit interaction 2Lec (ix) Lande Interval Rule, Hole formalism and equivalency, Hund's third rule and energies of J levels, Russel-Saunders coupling of d2 system and j-j coupling 3Lec (x) Thermal energy and magnetic property, Magnetic moments for different multiplet widths i.e for multiplet width large compared to KT, small compared to KT and comparable to KT 3Lec (xi) Magnetic properties of Lanthanides, first transition series metal ions and actinides 2Lec (xii) Determination of magnetic susceptibility: Gouy's method, Faraday's method, NMR method and their advantage and disadvantages, magnetic anisotropy. 3Lec (xiii) Magnetic properties of complexes with different geometries based on crystal field model, spin-state equilibrium in octahedral stereochemistry, magnetic properties of high-spin, low-spin, intermediate-spin and admixed-spin state concept. 2Lec (xiv) Quenching of Orbital magnetic moment by crystal field, loss of orbital degeneracy and quenching of orbital magnetic moment, valence bond and crystal field interpretation of magnetic moment, shortcomings of crystal field theory. 2Lec
Text Books, and/or reference material	1. Inorganic chemistry, Shriver & Atkins, Oxford. 2. Concept and models of inorganic Chemistry, Douglas, Mcdeniel, Alexander, Wiley. 3. Inorganic Chemistry, Huheey, Kieter, kieter, Medhi, Pearson education 4. Concise Inorganic chemistry, Lee, Wiley indiaPvt. Ltd 5. Elements of magnetochemistry by Dutta & Shyamal 6. Mechanisms of Inorganic Reactions by Fred Basolo and Ralph Pearson

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	1	1	3	3	1	1	1
CO2	3	1	3	3	1	1	1	3	1	1	1	1
CO3	3	1	3	3	1	1	1	3	1	1	1	1
CO4	3	2	3	2	2	1	3	3	3	3	1	1
CO5	3	2	3	3	2	1	3	3	3	3	1	1
CO6	3	2	3	3	2	3	3	3	3	3	1	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC703	**Concept of organic synthesis and asymmetric synthesis**	PCR	3	1	0	4	4

<table>
<tr><td colspan="2">Pre-requisites</td><td>Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td>CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">CO1: A complete knowledge on tactics, strategy and control for the synthesis of organic compounds has been elaborately discussed using some specific reagents for particular compound synthesis.
CO2: How the better yield of product could be obtained, their tactics, strategy and control has been highlighted.
CO3: Role of specific reagents with related mechanism in their transformation and mechanistic path from substrate to products is included for their step by step reactions.</td></tr>
<tr><td>Topics Covered</td><td colspan="2">Planning Organic Syntheses:
Tactics, Strategy and Control; Slectivity: chemoselectivity, regioselectivity, streoselectivity: 2L
Making Carbon-carbon single and double bonds: Enolates, homoenolates, extenddenolates, nitrogen analogues of enols and enolates, acyl anion equivalents, allyl anions, specific enol equivalents, Michael reaction, σ-complexes of metals, orgnometallic reagents, aldol addition and condensation reactions, Mukaiyama aldol condnsation, control of facial reactivity, Claisen and Dieckmann condensation, conjugate addition, orthostrategy for aromatic compounds, reactions involving carbocation, carbenes and radicals, vinyl anion equivalent, allyl cation equivalent, Palladium catalysed coupling reactions.
Olefination reactions – wittig and related reactions, Julia olefination. Sulfenylation and selenenylation, hydroalumination, carboalumination, ROMP and RCMP. 8 L
Functional group interconversions and Retrosynthetic analysis: Synthones and synthetic equivalents, functional group interconversions and order of events in organic synthesis. One group - C-X and two groups C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis. One group C–C and two group C–C disconnections (typical examples), use of acetylenes and aliphatic nitro compounds in organic synthesis. Diels-Alder reactions, 1,3- and 1,5-difunctionalised compounds, α, β-unsaturated carbonyl compounds, control in carbonyl condensation, Michael addition and Robinson annealation. Ring synthesis: saturated heterocycles synthesis of 3-, 4-, 5-, and 6-membered rings, aromatic heterocycles in organic synthesis. 8L
Classic total synthesis of some natural products: Strategies and synthesis of some classic examples of total synthesis; Periplanone B, penicillin V, reserpine, erythronolide B, thienamycin, biotin, menthol, strychnine by Woodwards method. 10L
Asymmetric synthesis: Control of stereochemistry, chiral pool, asymmetric induction via reagents, asymmetric induction via substrate, asymmetric induction via catalysis, kinetic resolution, enantiomerically pure compounds and sophiscticated synthesis. 8L</td></tr>
</table>

Text Books, and/or reference material	Suggested Text and reference Books: ● Organic Chemistry by J. Clayden, N. Greeves, S. Warren & P. Wothers, Oxford University Press, 2001 ● Organic synthesis strategy and control by P. Wyatt & S. Warren, Wiley, 2007. ● Advanced Organic Chemistry by F.A. Carey & R.J. Sundberg, Springer, 2007. ● Principles of Organic Synthesis, R.O.C. Norman & J.M. Coxon, Nelson Thrones, 1993, CRC Press. ● Organic synthesis by M. Smith, Elevier, 4th Edition, 2016. ● 6. Classics in Total Synthesis: Targets, strategies and Methods by K.C. Nicolaou& E.J. Sorensen, Wiley, 1996. ● 7. Modern Methods in Organic Synthesis by W. Carruthers, Cambridge University Press, 2004. ● 8. Protective Groups in Organic Synthesis by T.W. Green & P.G.M. Wuts, Wiley, 2002.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	3	2	3	3	3	1	3	2
CO2	3	3	2	3	2	2	3	2	3	3	1	2
CO3	3	2	3	2	1	3	2	3	2	2	1	2

Course Code	Title of the course	Program Core (PCR)/Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC704	**Mathematicaland computational chemistry**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment(EA))					
NIL		CT+EA					

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Course Outcome	• CO1:Foundationinbasicmathematicaltechniquesthatarecommonlyusedinchemistry. • CO2:Learntheartofscientificprogrammingtosolvechemicalproblems. • CO3:Writesimpleprogramsformatrixdiagonalisation,solvenumericaldifferentiation,integration and elementarydifferential equations. • CO4:Applycomputationalmethodstocomplexproblemsofgrouptheory,quantumchemistry,molecularspectroscopy,chemicalkineticsandothertopics. • CO5:Introductiontocomputationalchemistrysoftwarepackagesforquantum mechanicalandmacromolecularmodelling.
Topics Covered	Complexnumbersinchemistry:representationofcomplexnumber,Euler'sformula,rotational operators, periodicity, periodicity in circle, Periodicity in line, rotation inquantummechanics. 2 Lec Linearalgebrainquantummechanicsandsymmetryoperation:Vectorspace,determinants, matrix and liner transformations, orthogonal transformation,symmetryoperations,matrixeigenvalueproblemetc. 3LecDifferentialequationandchemistry:rateprocess,harmonicoscillator,waveequationfor harmonic oscillator,particle inbox, particle inaring 2LecTheLegendre equation,Legendrepolynomials,associatedLegendre polynomial,orthogonalityandnormalisation,Hermiteequation,Laguerreequation,associatedLaguerrefunctions,separableequationinchemicalkineties. 2 LecPartialdifferentialequation:generalsolution,separationofvariable,particleinarectangularbox,inacirclebox,hydrogenatom,vibratingstring,normalmodesofvibration. 3 Lec Function in three dimension: spherical polar coordinates, Density functions, atomicorbitals, volume integrals, average value, Maxwell velocity distribution, Laplacianoperatoretc. 3 Lec Fourier Transform in IR and NMR spectroscopy and X ray diffraction: orthogonalexpansions and Fourier analysis, Fourier series, periodicity, Fourier transforms,Fouriertransformpairsandapplicationin IR,NMRandX-raysdiffraction. 3 Lec Introduction to Fortran/Python language: data types, integer, complex, character,logicalconstantsandvariables.Arithmeticstatements,expressions,libraryfunction,relationaloperators. 2Lec Inputandoutputstatements,I/Oformatstatements,differenttypesofcontrolstatements. 1Lec Loop structures, subscribed variables and arrays. Writing and executing of simpleexampleprogrammes. 2 Lec Programmingexercisestochemicalproblems 5Lec - ApplicationofDensityFunctionalTheoryusingGaussian(orsimilar)softwareinchemistry. 5 Lec Basicconceptonmacromoleculemodellingsoftware. 3Lec

Text Books, and/or Reference material	1. TheChemistryMathsBooks, ErichSteiner, Oxford 2. Mathematicsforchemistry, DoggettandSuiclific,Logman. 3. MathematicalforPhysicalchemistry: F.Daniels,Mc.GrawHill. 4. Chapman,Fortran95/2003forScientistsandEngineers,McGraw-HillInternationalEdition, New York (2006). 5. V.Rajaraman,ComputerProgramminginFortran90and95,PHILearningPvt.Ltd, New Delhi (1997). 6. W.H.Press,S.A.Teukolsky,W.H.Vetterling,B.P.Flannery,FortranNumericalRecipes (Fortran 90),CambridgeUniversityPress(1996) 7. UserReferenceManualforGaussian09software

MappingofCO(Course Outcome)andPO(ProgrammeOutcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	3	3	3	2	1	2	3
CO2	3	3	3	2	2	3	3	3	2	1	2	3
CO3	3	3	3	2	3	3	3	3	2	1	2	2
CO4	3	3	3	2	3	3	3	3	2	1	2	2
CO5	3	3	3	2	3	3	3	3	2	1	2	2

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS751	**Spectro photochemical Analysis**	PCR (Practical)	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous(CT) and end assessment(EA) along with Viva-Voce)
NIL	CT and Viva-voce

Course Outcome	• CO1:Basicconceptsofspectrophotometric estimation

(Thestudents will master thefollowing)	• CO2:Learningabouthandlingofspectrophotometerandfluorescencespectrometerand theirbasic theory. • CO3:Todeveloplaboratoryskillsandtheabilitytoworkindependentlyaswellasin a group. • CO4:Knowingpresentation,analysisandinterpretationofdata,sourceoferrorand error analysis. • CO5: To understand the interconnection betweenexperimental foundationandunderlyingtheoretical principles. • CO6:Todeveloptheabilityofscientificcommunicationsthroughoralquizzes, writtenreportsandpresentations.
Topics Covered	1. DeterminationofstoichiometryofFerricsalicylicacidcomplexbyJob's method 2. Determinationofindicatorconstantofmethylorange 3. DeterminationofconcentrationofCu^{2+}andFe^{3+}photometricallybytitratingwith EDTA 4. Determinationofarsenic(III)andantimony(IV)simultaneouslyina mixturespectrophotometrically. 5. Determinationofmolarextinctioncoefficient 6. Determinationoffluorescencequantumyield. 7. Fluorescencequenchingexperiment:determinationofmicellaraggregationnumber. Someadditional experimentsas decidedbythe Instructor.
Text Books, and/orReference material	1. Instruction manual provided by the Instructor 2. ExperimentsinPhysicalChemistrybyCarlGarland,JosephNibler,DavidShoemaker 3. Practicalsin PhysicalChemistrybyPS Sindhu 4. PracticalPhysicalChemistrybyViswanathan andRaghavan

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									
CO2	3	3		2	2	3		2	2		1	
CO3						2		2	2		3	3

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS752	**Spectrophotometric Estimation of Cations and Anions**	PCR (Practical)	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA) along with Viva-Voce)
NIL	CT and Viva voce
Course Outcome (The students will master the following)	• CO1: Basic concepts of spectrophotometric estimation • CO2: Understand to evaluate the estimation of ion mixture • CO3: Learning about handling of spectrophotometer • CO4: Understand the fundamental, scientific basis, preparation of sample, sampling method and analytical methods for water and waste water samples. • CO5: Students will also accumulate idea about the permissible limit, present concentration etc. of different environmental impurities.
Topics Covered	Estimation of $MnO4^{-}$ –$Cr_2O_7^{2-}$ mixture Estimation of Cu^{+2}–Zn^{+2} mixture Estimation of NO_3^{-} –PO_4^{3-} mixture Estimation of Ti^{+4}–V^{+5} mixture Estimation of dissolved oxygen and oxygen demand (BOD and COD) of Environmental Samples Some more experiments from the followings as decided by the Instructor. (i) Determination of Ni in steel (Gravimetrically). (ii) Analysis of Brass and Aluminum in Bronze, (iii) Spectroscopic determination of Iron in Bauxite
Text Books, and/or reference material	1. An Advanced Course in Practical Chemistry by Nad, Ghosal and Mohapatra, New Central Book agency. 2. A Manual of Practical Chemistry for Degree Classes (Vol I & II) by R. C. Bhattacharya, 3. College Practical chemistry by Ahluwalia, Dingra and Gulati. 4. Vogels textbook of quantitative chemical analysis By J Mendham, R. C. Denney, M. Thomas and D. J. Barnes, Pearson India. 5. APHA, A, WEF, (1998). Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works Association,Water Pollution Control Federation, Washington DC.

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	3		3	2	1	1	
CO2	3	2	1	2	1	2	1	3	2	2	1	1
CO3	3	2	3	2		3	3	3	2	2	1	
CO4	3	3	3	3	3	2	1	3	3	3	2	3
CO5	3	2	3	2	3	2	1	3	3	3	3	3

CYS753	Separation and Identification of Organic Compounds from Binary Mixture	PCR (Practical)	L 0	T 0	P 4	H 4	C 2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA)and Viva-Voce)					
CYS351		CT + Viva-voce					
Course Outcome (The students will well-acquainted with)	CO1: Scientific knowledge on principle of separation techniques to reach a targeted pure separate component from a binary mixture, CO2: Become skilled to optimise the uses of solvent obeying the principle of green chemistry. CO3: Separation and purification techniques, like phase transfer, crystallization, GC-Mass and other spectroscopic method will be adopted CO4: Understand the basic concept behind separation process for most common different methodology and their principles like; distillation, sublimation, crystallization and solvent extraction will be adopted. CO5: To reach a maximum yield with minimum uses of solvent, reagents and energylike; heat and electricity (Green chemistry).						
Topics Covered	1. Aniline and benzil (Liquid and solid) 2. Ethyl acetoacetate and Benzoic acid (Liquid and solid) 3. Benzil and Benzoic acid (solid and solid) 4. p-chlorobenzoic acid and aniline (solid-liquid) 5. Cyclohexanone/ cyclohexanol and N,N dimethyl aniline (liquid and liquid) In each case, separation and identification of individual components, preparation of derivatives of each component, their purification and characterization.						
Referenc e material	1. *Vogel's* Textbook of practical *organic* chemistry, 5th Edition 2. Advanced *practical* chemistry, 3rd ed.: Subas C. Das 3. An Advanced Curse in Practical Chemistry, New Central Book Agency; 3rd ed.: Nad, Mahapatra and Ghoshal						

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	1	3	2	2	1	2
CO2	3	3	2	2	2	2	2	3	2	2	1	2
CO3	3	2	3	2	2	2	2	2	2	2	1	2
CO4	3	2	3	2	3	3	1	3	2	3	1	2
CO5	3	3	2	2	3	3	2	3	2	3	1	2

EIGHTH SEMESTER

Course Code	Title of the course	Program Core (PCR) /Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC801	**Chemical, Statistical Thermodynamics and Electrochemistry**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment) (EA))
NIL	CT+EA

Course Outcome	• CO1:understand the thermodynamics ofideal,non-ideal and multicomponentsystems. • CO2: understand the concept ofentropy of a system at absolute zero and itsimplication. • CO3: account for physical interpretation of partition functions and able to analysethermodynamic properties of model systems with using Boltzmann, Fermi-DiracandBose-Einstein statistics. • CO4:understandtheionicpropertiesinsolution,likediffusion,migration,conductionand theirinterrelation. • CO5: account for fundamental ideasofDebye-Huckeltheoryanditsapplication.
Topics Covered	**Third law of thermodynamics:** Thirdlawofclassicalthermodynamicsandtheirapplications. 2L **Thermodynamics of non-ideal solution:** Thermodynamicsofidealandnonidealbinarysolutions:freeenergyand entropyofmixing,partialmolarquantitiesandtheirdetermination,fugacityandits determination, 4L Gibbs-Duhemequation,Duhem-Margulesequation,equilibriumconstant, temperaturedependent equilibrium constant. 3L Thermodynamicexcessfunctions.Experimentaldeterminationofactivity coefficientofelectrolytes andnonelectrolytes. 3L **StatisticalThermodynamics:** Introductiontostatisticalthermodynamics,probability,ensemblesanddistributionlaws. Partition function. 2L ComparisonamongMaxwell-Boltzmann,Fermi-DiracandBose-EinsteinStatistics. 2L Statisticalmechanicsonthethermodynamicsofmono,diatomicandpolyatomic ideal gas-contribution of rotation, vibration and translation topartitionfunction. Concept of residual entropy. 4L

	Electroniccontributiontothespecificheatofdiatomicgases. Solids- vibrational contribution to the specific heat of solids.Statisticaltreatment of Black-bodyradiation. Maxwell-Boltzmannprobabilitydistributionofmolecularvelocitiesandspeeds. Dynamicsofchemicalreactioninsolution-transitionstatetheoryusing partitionfunctions. 6L **Electrochemistry:** Somepreliminaryconceptofelectrostatics. 3L Ion-solventinteraction:Bornequation,Electrostrictionandpartialmolarvolume. Solvation number of electrolytes. Dielectric constant of solution.Effectofnonelectrolyte onion-solventinteraction.Ion-dipoleinteraction. 4L Ion-ion interaction: Debye-Huckel-Onsagar theory of inter-ionic interaction,thicknessof ionicatmosphere.Debye-Huckel limitinglaw. 4L Ion transport in solution: Fick's first and second law of diffusion, Molecularinterpretation of diffusion, Migration of ion under electric field, Effect ofviscosity and diffusion on ionic migration. Relaxation of ionic atmosphere,Effectof highelectricfield and highfrequencyofionicconduction. 4L Rate processapproachtowards ionicmigration:Nernst-PlanckFluxequation anditsapplication. 3L Transportofionthroughmembrane:Donanequilibrium. 2L
Text Books, and/or Reference material	1. Modernelectrochemistry:Ionics(Part1);andElectrodics(Part2)byBockrisand Reddy 2. AnintroductiontostatisticalthermodynamicsbyT.L.Hill 3. PhysicalChemistry:StatisticalMechanicsbyH. Metiu(TaylorandFrancis) 4. PhysicalChemistry:ThermodynamicsbyH.Metiu(Taylorand Francis) 5. ChemicalThermodynamics:PrinciplesandApplications;andAdvancedApplication sby Ott andGoates

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			2		2	3	3	2	2	1	1
CO2	3			2		2	3	3	2	2	1	1
CO3	3		2	2		2	3	3	2	2	1	1
CO4	3	3	3	2	2	3	3	3	2	3	1	1
CO5	3			3	1							

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC802</td><td>Organometallic Compounds and Bioinorganic Chemistry</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA)</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Course Outcome (Students will be enriched by)</td><td colspan="6">CO1: knowledge of s, p and d block organometallics in respect of synthesis, structure and bonding in different ligand environment.
CO2: knowledge of different types of reactions of organometallics compounds and their role in different catalytic cycles related to industrial processes.
CO3: understanding the role of trace elements in health and environment, chemistry of metal cytotoxicity and its remedy.
CO4: knowledge the structure and function of metalloenzymes and metalloproteins with special emphasis of iron storage, oxygen transport and photosynthesis.
CO5: application of modern spectroscopic tools to elucidate the active sites of metalloenzymes and metalloproteins.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Gr. I and Gr. II organometallics: synthesis, properties and application. 2 lec
d –metal organometallics: History, stable electronic configuration, 18 and 16 electronic system, electron count and oxidation state, Nomenclature, π- acid ligands and low oxidation states 3 lec
Metal carbonyl: Binary carbonyl: synthesis, bonding, spectroscopic characterisation of carbonyl compounds, 4 lec
Substituted carbonyl: phosphine, isocyanide, nitrosyl, dinitrogen, carbenes, hydrides, and dihydrogen, η1 alkyl, alkenyl, alkynyl, aryl, η2 alkene, alkyne, nonconjugateddiene, , butadiene, cyclobutadiene, cyclotetracene, allyllgand, cyclpopentadiene, and cycloheptatriene, Metallocenes: synthesis, reactivity and bonding of ferrocene etc. 6 lec
Reactions: ligand substitution oxidative addition and reductive elimination, σ-bond metathesis, 1,1 migratory insertion, 1,2 insertion, β-hydride elimination, Homogeneous catalysis: hydrogenation catalyst, hydro formylation, Wacker oxidation of alkenes, asymmetric oxidation, metathesis 5 lec
Cage and metal clusters. 3 lec
Bio-inorganic:
Occurrence and availability of inorganic elements in organisms; essential, beneficial and trace elements, Synergistic and antagonistic relationship of metal ions, Element deficiency and toxicity, Metal poisoning detoxification 1 lec</td></tr>
</table>

	Biological ligands for metal ions: Nucleobases, nucleotides and nuclic acids (DNA, RNA) as ligands, tetrapyrrole ligands and other macrocycles (chlorin, corrin), Concept of protein structures: primary, secondary, tertiary and quaternary; Coordination of proteins and comments on enzymatic catalysis 1 lec Cobalamins including vitamin and Coenzyme B12: History and structural characterisation; Reactions of the alkylcobalamins (a) One-electron reduction and oxidation, (b) Co-C bond cleavage, (c) Mutase activity of Coenzyme B12 and (d) alkylation reactions of Methylcobalamins; Model systems and the role of the Apoenzyme 3 lec Metals at the center of photosynthesis: Total efficiency of photosynthesis; Primary processes in photosynthesis such as (a) Light absorption, (b) Exciton Transport, (c) Charge separation and electron transport (Photosystem-I, Photosystem-II, Z-Scheme); Manganese catalysed oxidation of H_2O to O_2 4 lec The dioxygen molecule, O_2 Uptake, transport and storage: Molecular and chemical properties of O_2, Oxygen transport and storage through Hemoglobin and Myoglobin, Alternative oxygen transport by some lower animals by Hemerythrin and Hemocyanin, Active site structure elucidation using magnetism, light absorption, vibrational spectroscopy and Mössbauer spectroscopy4 lec Uptake, transport and storage of an essential elements as exemplified by Iron: Iron mobilization problem-----Oxidation states, solubility and medical relevance; Siderophores (Fe uptake by microorganism), Phytosiderophores (Fe uptake by plants), Transport and storage of iron (Transferrin, Ferritin, Hemosiderin) 4 lec Copper containing proteins as an alternative to biological iron: Type 1 blue copper center, Type 2 and Type 3 copper centers in O_2 activating proteins, Copper proteins as Oxidases/Reductases, Cytochrome c Oxidase, Cu-Zn and Ni superoxide dismutases. 4 lec
Text Books, and/or reference material	1. Concept and models of inorganic Chemistry, Douglas, Mcdeniel, Alexander, 2. Inorganic chemistry, Shriver & Atkins, Oxford 3. Inorganic Chemistry, Huheey, Kieter, kieter, Medhi, Pearson education. 4. The Organometallic Chemistry of the Tr. Metals by Robert H. Carbtree. 5. Bioinorganic chemistry by Bertini, Gray, Lippard and Valentine.

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	2	2	3	3	2	1	1
CO2	2	2	3	2	2	2	2	3	3	1	1	1
CO3	2	3	3	2	2	2	2	3	3	3	1	1
CO4	3	3	3	1	2	2	3	3	3	3	1	1
CO5	3	3	3	1	1	3	3	3	3	2	1	1

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC803</td><td>Pericyclic Reactions and Organic Photochemistry</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA)</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">● CO1: Understand the basic principles of pericyclic and organic photochemical reactions
● CO2: Understand the classification of different types of pericyclic and organic photochemical reactions
● CO3: Solving mechanism of pericyclic and organic photochemical reactions
● CO4: Understand the application of pericyclic and organic photochemical reactions</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Pericyclic Reactions(18L):
Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. 3L
Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO & PMO approach. 3L
Electrocyclic reactions-conrotatory and disrotatory motions. 4n, 4n+2 system 4L
Cycloaddition – antarafacial and suprafcial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheletropic reactions. 4L
Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon moieties, 3,3- and 5,5 sigmatropic rearrangements. Claisen, cope and aza-cope carbon rearrangements. Fluxional tautomerism, Ene reactions. Recent advances from current literature. 4L
Organic Photochemistry (20L):
General information, Photo-chemical energy, effect of light intensity on the rate of photochemical reactions. Jablonski-diagram, photo-sensitisation and quenching.
Norrish tyoe-I, type-II processes, Paterno-Buchi reaction, photochemistry of unsaturated compounds. 4L
Types of photochemical reactions: Photo-dissociation, gas phase photolysis. Photochemistry of alkenes: Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes. 3L
Photochemistry of Carbonyl compounds: Intramolecular reactions of carbonyl compounds saturated, cyclic and acyclic,β,γ-unsaturated and α,β-unsaturated compounds. Cyclohexadienones,Intermolecular cycloaddition reactions, dimerisation and oxetane formation. 4L</td></tr>
</table>

	Aromatic compounds: Isomerisations, additions and substitutions. Miscellaneous photochemical reactions: Photo-Fries reactions of anilides, photo-fries rearrangement, Barton reaction, Singlet molecular oxygen reactions. 3L Photochemical formation of smog. 1L Photodegradation of polymers, photosubstitution, photoreduction of ketones, photooxidation, di-π methane rearrangement, photochemistry of arenes. 3L Organo-metalic photochemistry, photochemistry of vision. 2L
Text Books, and/or reference material	1. Molecular Orbitals and Organic Chemical Reactions by I. Fleming, Wiley. 2. Pericyclic reaction By S. Sankararaman Wiley VCH, 2005. 3. Photochemistry and Pericyclic Reactions by Jagdamba Singh, New Age Science publisher 4. Mechanism of Organic Chemistry by Peter Sykes

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	3	1	3	2	1	2	2
CO2	3	3	3	2	2	3	1	3	3	1	1	2
CO3	3	3	3	3	3	3	2	3	3	2	2	3
CO4	3	3	3	3	3	3	2	3	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE811	Advanced Natural Products and Medicinal Chemistry	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT)and end assessment (EA)					
NIL		CT+EA					

Course Outcome (The students will master the following)	• CO1:Understanding the importance of natural products • CO2: Learning of the structure, synthesis and uses of different Terpenes • CO3: Know the chemistry of Steroids in hormones • CO4: Develop knowledge of the chemical structure, synthesis of different natural pigments • CO5:Concept generation on rational medicinal chemistry and classification • CO6: Introduction to drug manufacturing done in pharmaceutical industries • CO7:Fundamental use of computer in drug design and discovery	
Topics Covered	Terpenes: Structural studies on sesqui terpenes, diterpenes, triterpenes and carotenoids; chemistry of carryophyllene, abietic acid, beta-amyrin, alpha and beta-carotenoids	9Lec

	Steroids and Prostanoids: Reaction and synthesis of steroids, sources of steroid hormones; diosgenin, hecogenin, etc., structure and synthesis of prostanoids	9Lec
	Natural Pigments: General methods of isolation, structure elucidationandsynthesisofanthocyanins,flavones,flavones,isoflavones, aurone, chalcone, xanthone and their chemical interconversions	9Lec
	Medicinal Chemistry: Definition, Concepts of LD50 and ED50, introduction to rational approach to drug design, physical and chemical factors associated with biological activities, structure-activity relationship, and mechanism of drug action. Classification of Medicine: Based on structure or pharmacological basis with examples. Antineoplastic agents, cardiovascular, local anti-infective, psychoactive, antibiotics (including vancomycin). Industrial synthesis of important medicines. Modelling: Molecular modeling, conformational analysis, qualitative and quantitative structure-activity relationship.	9Lec
TextBooks, and/or reference material	4. Asymmetric Synthesis of Natural products By Ari M PKoskinen (Wiley) 5. Chemistry of Natural products By S BBhat,B A Nagasampagi, M Sivakumar (Narosa) 6. Medicinal Chemistry: An introduction By Gareth Thomas (Wiley) 7. An Introduction to Medicinal Chemistry by GL Patrick (Oxford)' 8. Bioinformatics and Computational Biology in Drug Discovery and Development by William T. Loging (Cambridge)	

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	1	2	1	2	3	3	1	1
CO2	3	1	1	1	1	2	1	3	2	2	2	1
CO3	3	2	1	1	1	3	1	3	3	3	1	1
CO4	3	1	1	1	1	2	1	2	2	3	1	1
CO5	3	3	3	3	3	3	1	3	3	1	3	1
CO6	3	3	3	3	3	3	1	3	3	1	3	1
CO7	3	3	3	3	3	3	3	3	3	1	3	1

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE 812	**Spectroscopic methods of analysis**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	· CO1: Understanding the principle and applications of UV-VIS, IR and Raman spectroscopy to elucidate the structure of different organic and inorganic molecules. · CO2: Understanding the principles of ESR spectroscopy and its application in the structure determination of inorganic complexes and reactive intermediates involved in organic and inorganic reactions. · CO3: Understanding the basic concept of Mössbauer Spectroscopy and usefulness of this technique to the studies of bonding and structures of inorganic compounds. · CO4: Understand the core concept of Mass Spectroscopic techniques and their contribution to the methods of structure elucidation of organic and inorganic species. ● CO5:Understand the different aspect of Nuclear Magnetic Resonance spectroscopy and its application in the field of structure determination of organic and inorganic species
Topics Covered	1. Applications of UV-VIS, IR and Raman spectroscopy to elucidate the structure of different organic and inorganic molecules. 4 Lecs 2. ESR spectroscopy: Hyperfine coupling, Spin polarization for atoms and transition metal ions, Spin-orbit coupling and significance of g-tensors, application to transition metal complexes including free radicals. 4 Lecs 3. Mössbauer Spectroscopy Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of i) bonding and structures of FeII, FeIII compounds including those of intermediate- spin, ii) SnII and SnIV compounds, nature of M-L bond, coordination number and structure and iii) detection of oxidation states. 4 Lecs 4. Mass Spectroscopy Generation of ions and detection; EI, CI, FD, FAB, plasma desorption etc; fragmentation pattern in EI, GC-MS, MS-MS, LC-MS. Application of UV, IR, NMR and MS in structure elucidation. 8 Lecs 5. NMR Spectroscopy Long-range spin-spin interaction. Interpretation of non-first order NMR; double resonance, Lanthanide shift reagent, spin-tickling, INDOR, NOE, effect of solvents (aliphatic and aromatic), preliminary idea on 19F, 31P, 14N, 15N, 17O. NMR of solids, NMR imaging. 13C NMR Spectroscopy: Introduction, theory, instrumentation, chemical shift, coupling constants, application in organic molecules. 15 Lecs
Text Books, and/or reference material	1. Elements of magnetochemistry: Dutta and Shyamal 2. 2. Fundamental concept of Inorganic Chemistry (Vol-7): A. K. Das 3. Structural methods in molecular inorganic chemistry: Rankin, Mitzel, Mosrision 4. NMR spectroscopy (Basic Principles, concepts and application in chemistry): H. Gunther 5. Spectrometric identification of organic compounds: Robert Silverstein 6. Organic spectroscopy: William Kemp 7. Structural methods in Inorganic Chemistry : Ebsworth, Rankin and Cradock

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

Mapping of CO (Course outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS851	**Advanced Physical Chemistry Practical**	PCR			4	4	2

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment) (EA))
CYS751	CT and viva-voce

Course Outcome (The students will	• CO1: Basic concepts of spectrophotometric estimation and IR spectroscopy. Experimental knowledge on the influence of reaction parameters on the rate of there action, and analysis thereon. • CO2:LearningabouthandlingofspectrophotometerandIRspectrometerand their basic theory.
Topics Covered	1. DeterminationofisoelectricpHofgelatin. 2. Rateconstantofalkaline hydrolysisofcrystalviolet 3. Salteffectonthe rateof alkalinehydrolysisofcrystalviolet 4. Solventeffectonthe rateofalkalinehydrolysisofcrystalviolet 5. Micellareffectontherateofalkalinehydrolysisofcrystalviolet 6. IntermolecularhydrogenbondinginbenzylalcoholusingIRspectroscopy 7. Thermodynamicsofmicellization. 8. Determinationofactivationparameterofareaction. 9. Determinationofmean ionicactivitycoefficientofHClbyemfmeasurement.
Text Books, and/or Reference material	1. Instruction manual provided by the Instructor 2. ExperimentsinPhysicalChemistrybyCarlGarland,JosephNibler,DavidShoemaker 3. Practicalsin PhysicalChemistrybyPS Sindhu 4. PracticalPhysicalChemistrybyViswanathan andRaghavan

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									
CO2	3	3		2	2	3		2	2		1	
CO3						2		2	2		3	3
CO4	3	3		3	3		1	3				
CO5								3	3			
CO6								3	3		2	2

CYS852	**Synthesis and Characterisation of Complex Compounds**	PCR (Practical)	**L** 0	**T** 0	**P** 3	**H** 3	**C** 1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA) and Viva-Voce)					
NIL		CT + Viva voce					
Course Outcome (The students will well-acquainted with)	CO1: Coordination complex synthesis maintaining molarity. CO2: Crystallization techniques to purify the synthesized materials. CO3: Decomposition and estimation of metal ion(s) using spectrophotometry. CO4: Characterization of synthesized materials using FTIR, UV-Vis and EPR spectroscopy and CHN analysis. CO5: Spectral data interpretation.						
Topics Covered	Synthesis of a) $[VO(acac)_2]$; b) $[Co(NH_3)_5(N_3)]$; c) $[Mn(acac)_3]$; d) $(NH_4)_2[MnF_5]$; e) Mohr's salt and other complexes and their characterization using various spectroscopic methods. Estimation of metal ion of suitable complexes.						
Reference material	1. Advanced Inorganic Experiments, By G. N. MUKHERJEE.						

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	3	3	2	2	1	3	3	3	1	1
CO2	2	2	3	3	2	1	1	3	3	3	1	1
CO3	1	3	3	3	2	2	1	3	3	3	1	1
CO4	3	3	3	3	2	2	1	3	3	3	1	1
CO5	3	2	3	3	2	3	1	3	3	3	1	1

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYS853</td><td>Chromatographic Separation of Organic Compounds</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA)</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">• CO1: Understand the working principles of different types of chromatography.
• CO2: Learn the sampling method including derivatization for analysis
• CO3: Master the techniques and application of thin layer, paper and column chromatography
• CO4: Learn to analyze the chromatograms of GC and HPLC</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Thin Layer Chromatography
Determination of R_f values and identification of organic compounds.
Preparation and separation of DNP derivatives of carbonyl compounds
Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).
Paper Chromatography: Ascending and Circular
Determination of R_f values and identification of organic compounds.
Separation of a mixture of amino acids
Separation of sugars
Column Chromatography:
Separation of Fluorescein and methylene blue
Separation of aniline and N,N dimethyl aniline
Separation of Lycopene and β-carotene
Demonstration of chromatographic separation by GC & HPLC.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1. Fundamentals of analytical chemistry, Skoog, West, Holler and Crouch, 8th edition, Thomson</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	3	3	3	3	3
CO2	2	3	3	3	3	3	1	3	3	3	3	3
CO3	1	3	3	3	3	3	1	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CURRICULUM AND SYLLABUS FOR INTEGRATED MSC IN CHEMISTRY

NINTH SEMESTER

Course Code	Title of the course	Program Core (PCR) /Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE911	**Advanced Quantum Chemistry and Application of Group Theory**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment(EA))
CYC701, 704	CT+EA

Course Outcome	CO1: Different time dependent and time independent approximation methods tosolvevariousmolecularproblemswhenSchrödingerwaveequationcannotbesolvedexactly. CO2: Born-Oppenheimerapproximationtoseparatenuclearandelectroniccomponentsfrom molecular Hamiltonian. CO3:Detailedunderstandingontheinteractionofradiationwithmatterandselectionrulesfor transition amongdifferent molecularenergylevels. CO4:Hückeltheoryinconjugatedsystemanditapplications CO5: Development of concept of GOT, SALC from symmetry aspect and theirapplication CO6:Applicationsofgrouptheoryinspectroscopy,chemicalbonding
Topics Covered	Variationandtimeindependentperturbationtheory(nondegenerateanddegenerate cases):Applicationtowardsdifferentsystems. 08 lec Antisymmetricandexclusionprinciple,Slaterdeterminalwavefunction,spin-orbitalinteraction:LS andJJ coupling,Termsymboland spectroscopicstates.04 lec Moleculesand chemicalbonding: Born-Oppenheimerapproximation:MOandVBtreatmentofdiatomicmolecules. 04 lecDirectedvalenceandhybridizationinsimplepolyatomicmolecules.Ideaofself-consistentfield. 04 lec Timedependentperturbationtheory:Transitiondipolemoment.Fermi’sGoldenrule.Einstein’scoefficientsforinducedandspontaneousemission. 04 lec

	Hückeltheoryofconjugatedsystems.Bondorderandchargedensitycalculations.Applicationstoethylene, butadiene,cyclopropenylradical,cyclobutadiene.06lec Group theory: GOT, SALC: Their applications: representation of molecular orbitalsandshape 04 lec Application of Group theory in developing selection rules in spectroscopy02 lecApplicationincrystalfield theoryandmolecular orbitaltheory 02 lecConceptoforbital symmetryand applicationinchemical bonding 03lec Probabilityandefficiencyoftransitionsin IR and Ramanspectroscopy 03lec
Text Books, and/or Reference material	1. QuantumChemistrybyLevine 2.PhysicalChemistry: AMolecularapproachbyDonaldA.McQuarrie3.Introductoryquantum chemistrybyA. K.Chandra 4. Group theoryandchemistrybyBishop 5. Chemical applicationof group theorybyFA Cotton 6. MoleculartheoryandgrouptheorybyR.L. Carter

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	3	3	1	3	3	3	2	1	1
CO2	3	1	3	3	3	1	3	3	3	2	1	1
CO3	3	1	3	3	3	1	3	3	3	2	1	1
CO4	3	1	3	3	3	1	3	3	3	2	1	1
CO5	3	3	2	3	2	1	3	3	2	1	2	3
CO6	3	3	2	3	2	1	3	3	2	1	2	3

Course Code	Title of the course	Program Core (PCR)/Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE912	**Non-Equilibrium Thermodynamics and Biophysical Chemistry**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA))					
CYC401, CYC801		CT+EA					

Course Outcome	• CO1: difference between equilibrium and non-equilibrium thermodynamics andthe significance of the later. Understanding of different concepts and theories innon-equilibriumthermodynamics. • CO2: Concept on stationary state, coupled transfer (like diffusion and electriccharge, heat and electric charge), entropy production and application of theseconcepts. • CO3:Learningofdifferentbiophysicalprocessesinsideimportantbiomolecules • CO4:DevelopknowledgeonvariousinstrumentaltechniquesusedinBiophysicalChemistry
Topics Covered	**Non-equilibriumthermodynamics:** 15Lec Postulates and methodologies, forces and fluxes, linear laws, Gibbsequation,Onsagarreciprocaltheory.Curie-Prigogineprinciple,diffusion, effusion, sedimentation, chemical affinities, membraneproperties.Thermoelectriceffects. Stationary states: time variation of entropy production, minimumentropyproduction, stabilityof stationarystate.Fluctuation. **Biophysical Chemistry:** Enzyme kinetics and Enzyme inhibition: Introduction of Enzyme,Enzyme-substrateKinetics,Enzymeinhibition,Reversibleinhibition,Irreversible inhibition, Competitive Inhibitor, Allosteric Inhibitor,Non-CompetitiveInhibitor,Biophysicalandkineticsstudiesofenzyme-inhibitorcomplex,Enzymesasdrugtargets,pharmacokinetics,pharmacodynamics,ADMETprofile,examplesofenzymetargeted drugdiscovery. Nucleic acid structure and therapeutics: Biophysical of nucleic acid,sensing and anti-sensing of nucleotides, interactions between strandsofnucleicacid, strand-displacement assayas sensor. 5Lec Techniquesformacromolecularseparation:Ionexchange,gelfiltrationchromatography,sedimentation,electrophoresisandisoelectricfocusing, Bio-analyticalChemistry: (i) Applications of X-ray, AFM, UV-Vis, CD, fluorescence, NMR incharacterizationofbiological macromolecules. 2 Lec (ii) Applications of the FRET and AUC to study conformationaldynamicsof protein andnucleoproteincomplexes. 3Lec (iii) ApplicationsofUV-VisandITCtostudythekineticsandthermodynamicsof protein-ligand binding. (iv) Application of different gel-based assays (SDS-PAGE, NativePAGE,denaturingPAGE,Agarose)todeterminenucleicacidstabilityand DNArepairprocess. 10Lec (v) Applicationofpull-downmethodandsequencing toanalyzeprotein-DNAinteraction.

TextBooks,and/orreference material	1. IntroductiontoThermodynamicsofIrreversibleProcessesbyI.Prigogine 2. Principlesof Physical biochemistrybyHolde, Johnson and Ho 3. Experimentalbiophysical ChemistryByCopeland, R. A.

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2	2				3	2	1	1	
CO2	3		2	2				3	2	1	1	
CO3	3	3	3	2	2	3	2	3	2	2	2	1
CO4	3	3	3	2	3	2	2	3	2	2	1	1

Course Code	Title of the course	Program Core (PCR)/Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE913	**Material chemistry and advanced spectroscopy**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA))					
CYC701,801		CT+EA					
Course Outcome(The students will master the following)	• CO1:Fundamentalsoflaserandapplicationinscience andindustry • CO2: Properties and applications of semiconductors, superconductors,nanomaterials and manyotherindustriallyrelevant materials. • CO3:Physicalchemistryofpolymer. • CO4:sciencebehindmanymodernspectroscopicmethodsand applications						
Topics Covered	Laser: Fundamentals and applications, Time resolved laser spectroscopy(picosecond,femtosecondlaserspectroscopy)anditsapplication toinvestigatedifferentphotophysicalprocesseslikephoto-dissociation,photoisomerization(withareferencetovisionprocess)andrelatedtopics. 07 lec Freeelectrongastheoryofsolids: Fermi level,densityofstates. 04 lec Semiconductorandsuperconductor:propertiesand applications. 03 lec PhysicalChemistryofpolymers:Kineticsofpolymerization,thermodynamicsofmacromolecular systems. Determination of molar masses and studies ofconformationsandmorphologies,thermomechanicalpropertiesofpolymers.Sedimentationandultracentrifugationofmacromolecules. 07 lecFluorescencesensor,solarandfuelcell,supercriticalfluid,ionicliquids,Nanomaterials. 05 lec						

	Kineticsofdiffusioncontrolledreactions,photophysicalquenchingprocesses,excitedstatepHandacidityconstant,Charge-transferprocesses (Marcustheory). Experimentalmethodstoobserve kineticsoffastreactionsinsolution:stoppedflowandrelaxationmethods. 06 lec Advanced spectroscopy: NMR, X-ray photoelectron spectroscopy, Auger spectroscopy,Mossbouer spectroscopy,SEM 06 lec
Text Books, and/or Reference material	1. Modern spectroscopybyJMHollas 2. Solidstatechemistryandits applicationbyWest 3. ChemicalKinetics byK.J.Laidler 4. OrganicandphysicalChemistryofPolymersbyYGnanouandM.Fontaanille,Wiley 5. Atkin'sPhysicalChemistrybyPAtkinsandJ dePaula(7^{th}ed.) 6. Fundamentalsof molecularspectroscopyByBanwelland McCash 7. FundamentalsofphotochemistryByRohatgi and Mukherjee.

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	1	3	3		1	1
CO2	3	3	3	2	2	2	1	3	3	2	2	1
CO3	3	3	3	2	2	2	1	3	3	2	2	1
CO4	3	3	3	2	2	2	1	3	3	2	2	1

Course Code	Title of the course	Program Core (PCR)/Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE914	**Electrode kinetics and corrosion science**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment) (EA))
CYC801	CT+EA

Course Outcome (The students will master the following)	• CO1: process of adsorption and various adsorption isotherms involving different types of adsorbate-adsorbent combination. Application of adsorption isotherm to determine catalytic efficiency. • CO2: basics of surfactants and micelles and their application in science andtechnology. • CO3: concept of electrical double layer, zeta potential and its role for colloidalstability. • CO4: kinetics of reaction at the electrode surface and its relevance towardsindustriallyimportant hydrogen evolutionfrom dissociation ofwater. • CO5:corrosionofvariousmetalsunderdifferentenvironmentalconditionsand mitigationmethods.

	Adsorption on solid: BET,Harkins-JuraandGibbsadsorptionisotherms,surfacetensionandsurfacepressure, contactangle:interfacialtension,Hysteresis. 4 lec **Micellesandmicroemulsions:**Phasediagramofmicellarsystem.Massactionmodeland pseudophasemodelfornon-ionicandionicmicelles.Relationshipbetweenthermodynamicpropertiesformicellizati onwithCMC. 3 lecEstimationoffractionofcounterion,aggregationnumberandsolvationformicelles.C onceptofreversemicelleandmicroemulsion.Packingfactor. 4lecIon
	Electrical double layer: Electricaldoublelayer, Zetapotential,Stabilityofcolloids,Electrokineticeffect(electroosmosisandelectrophor esis) 3 lec **Electrode kinetics:** DerivationofButler-volmerequation,Studyofthekineticsofdifferentelectrodereactions(includingelucidat ion ofreaction mechanism).Numerical problems. 4 lec **Corrosion science:** Differentformsofcorrosion:propertiesandremedialmethods. 4 lec Tafelrelationandmixedpotentialtheory,Concept ofexchangeandlimitingcurrentdensity. 3 lec Potentio dynamic polarization and electrochemical impedance spectroscopic methods to determine rate of corrosion. 4 lecCorrosioncontrol:Cathodic(impressedcurrentmethodandmetalliccoating)andano diccontrolmethods.Numericalproblems. 4 lecApplicationofcorrosioninhibitorsincludinggreeninhibitors 2 lec Hightemperaturecorrosion 3 lec
Text Books, and/or Reference material	1. ModernElectrochemistry2A-FundamentalsofElectrodicsbyBockrisandReddy 2. CorrosionEngineeringbyMG Fontana 3. CorrosionEngineeringbyBNPopov 4. SurfactantscienceandTechnology(3rded.) byD. Myers. 5. Principles of colloid and surface chemistry (3rded)by PC Hiemenz and R Rajgopalan

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	1	3	3	3	3	1
CO2	3	3	3	2	2	2	1	3	3	3	3	1
CO3	3	3	3	2	2	2	1	3	3	3	3	1
CO4	3	3	3	2	2	2	1	3	3	3	3	2
CO5	3	3	3	2	2	2	1	3	3	3	3	2

CYS951	Advanced Physical Chemistry-II Laboratory	PCR (Practical)	L 0	T 0	P 3	H 3	C 1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment) (EA)and Viva-Voce)					
CYS751, 851		CT + Viva-voce					
Course Outcome (The students will well-acquainted with)	• CO1:basicunderstandingofvariousmodernelectrochemical,surfacecharacterization,spectroscopic techniques. • CO2:knowledgeonmeasuringtherateofcorrosionofmetals anditsmitigationbychemical route. • CO3:basicunderstandingonthedesignofsolarcell,nanomaterialpreparationandcharacterization. • CO4:developmentoflaboratoryskill,datahandlingandinterpretation,error analysis.						
Topics Covered	1. Determinationofrateofcorrosionofmetalusingpotentiodynamicpolarizationmethod 2. Determinationofrateofcorrosionofmetalusingelectrochemicalimpedancemethod 3. Evaluationofpotentialatzerochargeonametalsurfaceinpresenceofanelectrolyticsolution. 4. Determinationofcorrosioninhibitionefficiencyofanorganiccorrosioninhibitor. 5. Construction of a dye sensitized solar cell 6. Evaluationofexcitedstateprotontransferprocessin1-naptholbyexcitedstatelifetime measurement 7. Synthesisandcharacterizationofnanoparticles 8. Molecularmodellingprograms Any other practical as assigned by the Instructor						
Reference material	1. Instruction manual provided by the Instructor 2. Selected experiments in Physical Chemistry By N.G.Mukherjee 3. Advanced Physical Chemistry Experiments: By Gurtu & Gurtu						

Mapping of COs (Course outcomes) and POs (Programme Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3		3		3	3			
CO2	3	3	3	3	3	3		3	3	2	2	1
CO3	3	3	3	3	3	3		3	3	2	3	1
CO4				3	3						2	1

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYE921</td><td>Advanced Green Chemistry and Analytical Chemistry</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4.0</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcome (The students will master the following)</td><td colspan="7">

CO1: Students will be given an introduction to green chemistry and learn about its basic concepts.
CO2: Students will learn the application of green chemistry
CO3: Demonstrate the design for safer, energy efficient technology and process optimization for cleaner industrial processes.
CO4: Understand the fundamentals of pollution prevention technique with respect to health significance.
CO5: Fundamental Understanding of monitoring and analysis of air and water
</td></tr>
<tr><td rowspan="3">Topics Covered</td><td colspan="7">Introduction to Green Chemistry: 15 Lecture
Definition and strategic of green chemistry. Why Green Chemistry? Prevention, Atom Economy, Less Hazardous Chemical Syntheses, Designing Safer Chemicals, Safer Solvents and Auxiliaries, Design for Energy Efficiency, Use of Renewable, Feedstocks, Reduce Derivatives, Catalysis, Design for Degradation, Real-time analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention, Laboratory pollution prevention.</td></tr>
<tr><td colspan="7">Application of Green Chemistry: : 10 Lecture
Applications and benefits of green chemistry: Production of new chemicals, materials, and products. Examples of successful green technologies; Alternative synthetic routes, new separation processes, new methods for delivery or product application (Alternative solvents, Energy vs. material activity). Importance of pollution and wastefulness in modern cultures by reflecting on the green chemistry.</td></tr>
<tr><td colspan="7">Principle of Analysis for Air and Water samples: 10 Lecture
Objectives of chemical analysis of air and water. Analysis of water: colour, turbidity, total solid, conductivity, acidity, alkalinity, hardness, chloride, sulfate, fluoride, phosphates, and different forms of nitrogen. Heavy metal analysis with respect to health significance. Measurement of DO, BOD and COD. Pesticides as water pollutants analysis.
Monitoring and analysis of air: Monitoring technique through high volume sampler, SPM and RPM sampler. Measurement and analysis of SPM, RPM, SOX and NOX.
Air and water pollution laws and standards.</td></tr>
</table>

Text Books, and/or reference material	1. Green Chemistry, An Introductory Text By Mike Lancaster, RSC publications. 2. Handbook on Green Analytical Chemistry By Miguel de la Guardia, Salvador Garrigues, Wiley. 3. Innovations in Green Chemistry and Green Engineering By Paul T. Anastas, Julie Beth Zimmerman, Springer publications. 4. Alternative Solvents for Green Chemistry By Francesca M Kerton, Ray Marriott, RSC publications. 5. Environmental Chemistry with Green Chemistry By Asim Kumar Das, Books and Allied (P) Ltd.

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	1	3	3	3	2	3
CO2	3	2	3	2	3	2	1	3	3	3	3	3
CO3	3	2	2	2	3	2	1	3	3	3	2	3
CO4	3	3	3	2	2	3	1	3	3	3	3	3
CO5	3	3	3	2	2	3	1	3	3	3	3	3

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE922	**Synthetic Methodology for Metal Complexes and Coordination Aggregates**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CYC602 & CYC702		CT+EA					
Course Outcome (The students will master the following)		• CO1: Understand the importance of transition metal complexes • CO2: Basic knowledge of different types of ligands and their applications • CO3: Primary Concept of designing and synthesis of a ligand • CO4: Learn about the different aspects of supramolecular chemistry • CO5: Clear idea about the synthesis of diversified macrocycles • CO6: Fundamentals of thermodynamic effects upon changing the cavity size of a macrocycle					

Topics Covered	Introduction, Importance of ligand design and their applications in metal-complex formation	6 Lec
	Nitrogen Based Ligand: N_2 as Ligand, Reactivity of Bound N_2, Macrocyclic Amines, Polyimines, Porphyrin, Polypyrazolylborate Ligand, Hydroxylamido Ligand, Schiff Base Ligand, Azide and Other Anionic Ligand	5 Lec
	Phosphorus Based Ligands: Phosphine as Ligand, Monophosphines, Diphosphines, PolydentatePhosphines, Phosphate Ligands, Heterocyclic Phosphorus Ligands, Dialkyl- and Diarylphosphido Ligands	4 Lec
	Oxygen Based Ligand: Dioxygen, Sueroxo and Peroxo Ligand, Alkoxides and Aryloxides, Ketone and Ester, Crown Ethers, β-Ketoenolato and Related Ligands, Carbamates, Oxo Anions as Ligands	5 Lec
	Sulphur Based Ligand: Thiolates, Disulphides, Thioethers, Sulphur Oxide, Dithiocarbamates, 1,2-Dithiolenes	3 Lec
	Metal-Organic Frameworks	2 Lec
	Supramolecular Chemistry:	
	Introduction, Host-Guest Chemistry, SelfAssembly, Supramolecular Building Blocks and Spacer, Driving Forces for the Formation of Supramolecular Structure	2 Lec
	Spatial Relationships between Host and Guest, Classification Of Host-Guest Compounds, General Introduction To Podand, Coronand, Spherand, Coronand-Podand Hybrid, Cryptands	2 Lec
	The Chelate And Macrocyclic Effect On Host-Guest Binding, Synthesis of Crown Ethers, The Template Effect, Synthesis of Cryptands, Recent Developments in the Synthesis of Cryptands, Synthesis of Aza Crown Ethers and Related Compounds	3 Lec
	Chiral Crown Ethers, Proton Ionisable Crown Ethers, Diester Crown Ethers, Synthesis of Lariat Ethers	2 Lec
	Synthesis of Calix[n] Arenes, Chiral Calix[n] Arenes, Introduction of Functional Groups in Calix[n] Arenes, Reactions at Upper Rim of Calixarene	3 Lec
	Selectivity of Cation Complexation, Cation Binding by Crown Ethers, Cation Binding by Lariat Ethers, Cation Binding by Cryptands, Thermodynamic Effect of Binding	4 Lec
Text Books, and/or reference material	1. An Introduction to Supramolecular Chemistry by Asim K Das and Mahua Das. 2. Analytical Chemistry of Macrocyclic and Supramolecular Compounds by S. M. Khopkar. 3. Advanced Inorganic Chemistry by F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann. 4. Synergy in Supramolecular Chemistry edited by Tatsuya Nabeshima. 5. Concepts and Models of inorganic chemistry by B. E. Douglas, D. H. McDaniel and J. J. Alexander.	

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	--	3	3	2	--	1
CO2	3	3	3	3	1	--	1	3	3	1	1	1
CO3	3	3	3	3	2	2	--	3	3	2	--	1
CO4	3	--	3	2	2	2	1	3	1	1	1	1
CO5	3	3	3	3	2	2	1	3	3	2	1	1
CO6	3	--	3	2	2	1	1	3	2	1	--	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE923	**Small Molecule Activation, Nuclear Chemistry and Related Spectroscopy**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
CY1102, 2014	CT+EA

Course Outcome (The students will master the following)	Course outcome accounts of
	• CO1: Diversified biological roles of Nitric Oxide (NO) and the NO donor drugs. • CO2: Enemark-Feltham $\{MNO\}^n$ notation of metal nitrosyls and their spectroscopic and structural properties to elucidate structure-function relationship. • CO3: Active site structure and role of denitrifying bacteria responsible for nitrite (NO_2^-), nitric oxide (NO) and nitrous oxide (N_2O) reduction to N_2 sustaining global N_2 cycle. • CO4: Details of structure function of Metalloenzymes responsible for N_2 fixation, reverse process of denitrification. • CO5: Basics of nuclear chemistry, the nuclear spin (I), quadrupole moment (Q) and ellipticity of the nuclides and numerical problems. • CO6: The concepts and working principle of three spectroscopy such as Nuclear Magnetic Resonance (NMR), Electron Paramagnetic Resonance (EPR) or Electron Spin Resonance (ESR) and Mössbauer spectroscopy (specifically the last two) those are related to nuclear spin and the s-electron density of the nuclides.

Topics Covered	Importance of NO as ligand and its diverse roles in biology, NO Synthase enzyme and NO donors including metal nitrosyls, MO diagram of NO, Bonding nature of NO, Enemark-Feltham $\{MNO\}^n$ notation, Spectroscopic and structural properties of various $\{MNO\}^n$ species, NO detection methods, Electrophilic and nucleophilic reactivity on metal activated NO moiety 8 Lec Nitrite and Nitrous Oxide Reductase, their active site structures and catalytic activity and impact on Atmospheric Nitrogen Cycle 5Lec The N_2 fixation, Biological N_2 reduction using FeMo cofactor and Models, Chatt Cycle, Electrocatalytic reduction using low-valent tungsten (W), Mo(III) mediated N_2 reduction system, cleavage of N_2, Mo-N_2 complexes, N_2Redcution Mechanisms, Nitrogenase-related transformations 5Lec Concept of Quarks; Size, shape, stability and classification of nuclides, Nuclear potential diagram, Packing fraction, Mass defect, Binding energy and related numerical problems, Quantum numbers of nucleon and magnetic properties, Nordheim's rules, Nuclear magnetic resonance (NMR) and its application to medical diagnosis such as MRI, Electric quadrupole moment of the nuclides and concept of electric multipoles; Nuclear spin (I), quadrupole moment (Q) and Ellipticity of the nucleus and numerical problems 5 Lec Nuclear resonance or recoilless absorption and Mössbauer Spectroscopy; Recoiling Frequency shift, Frequency broadening and Doppler effect, Characteristics of Mössbauer nuclides and related Decay scheme, Quadrupole splitting, Isomer shift and its application to assign the spin states. 5Lec Electron spin resonance (ESR) spectroscopy: Interaction between electron spin and magnetic field, Techniques of ESR spectroscopy, Relaxation process and line widths in ESR transition, ESR relaxation and chemical bonding, Interaction between electron spin with nuclear spin: hyperfine/super hyperfine splitting, g values and factors affecting it, determination of g values, Zero field splitting, Kramer's degeneracy, applications of ESR measurement. 6 Lec Nuclear shell model, magic number and periodicity of nuclear properties, liquid drop model. 1 Lec Detection and measurement of radioactivity, Preparation of radio-isotopes, Cow and milk systems, Applications of radio-isotopes as tracers such as for chemical investigation, physico-chemical applications, age determination, medical applications, agricultural and industrial applications etc. 2Lec
Text Books, and/or reference material	1. Nitric Oxide Research (Eds. M. Feelish, J.S. Stamler) Wiley, Chichester, 1996. 2. Activation of Small Molecules, William B. Tolman, Wiley. 3. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, Wolfgang Kaim and Brigitte Schwederski, Wiley 4. Essentials of Nuclear Chemistry, H. J. Arnikar, New Age International Publishers, 2009 5. Nuclear Physics, Irving Kaplan, Narosa Publishing House, 2002 6. Modern Nuclear Chemistry, W. D. Loveland, D. J. Morrisey, Glenn T. Seaborg, Wiley. 7. Elements of Magnetochemistry, R. L. Dutta and A. Syamal

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	3	3	3	3	2	1	1
CO2	3	2	3	2	2	2	3	3	3	2	1	1
CO3	3	2	3	2	2	2	1	3	2	2	1	1
CO4	3	3	3	2	2	3	1	3	2	3	1	1
CO5	3	3	3	2	2	3	1	3	2	3	1	1
CO6	3	3	3	3	2	3	1	3	2	2	1	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE924	Group theory, applied electrochemistry and X-ray structure analysis	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+ EA

Course Outcome	Course outcome accounts of · CO1: matrix representation of operator, formation of character tables of different point group and its application in analyzing vibration and electronic spectroscopy of complex molecules. · CO2: Use of character table, symmetry and projection operator to learn hybridization and formation of SALC and LCAO which enable to understand bonding in molecules. ·CO3: foundation in different electrochemical methods like cyclic voltammetry, coulommetry and associated techniques to analysis inorganic complexes and evaluating kinetic processes occurring at the electrodes-solution interface. · CO4: knowledge of unit cell, symmetry and space group of different crystal. · CO5: idea of reciprocal lattice and its importance in structure elucidation of inorganic complexes using X-ray diffraction technique. · CO6: understanding of the working principle of various electrochemical instruments as well as X-ray diffractometer.

Topics Covered	**Group theory**: representation of groups, techniques and relationships for chemical applications, symmetry and chemical bonding, equation of wave functions, vibrational spectroscopy, transition metal complexes 12 lec **Electrochemistry**: fundamental of electrode reaction, basic equipment for electrochemical measurements, voltammetric techniques, coulometric techniques, electrochemical behaviour of transition metal complexes, metal complexes containing redox active ligands 12 lec **X-ray structure determination**: Diffraction of X-rays, Lattices, Plane and indices, X-ray diffraction. The reciprocal lattice, Brag's law in reciprocal lattice, crystal symmetry and space group, data collection, Intensity of data collection, theory of structure factors, and Fourier syntheses. 12 lec.
Text Books, and/or reference material	1. Electrochemical Methods: Fundamentals and Applications By Bard and Faulkner 2. Chemical applications of Group theory by F. A. Cotton 3. Molecular theory and group theory by R. L. Carter 4. Inorganic Electrochemistry: Theory, practice and application By P Zanello (RSC) 5. X-ray Crystallography By William Clegg (Oxford)

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	3	3	2	2	1	3	3	3	1	1
CO2	2	2	3	3	2	1	1	3	3	3	1	1
CO3	1	3	3	3	2	2	1	3	3	3	1	1
CO4	3	3	3	3	2	2	1	3	3	3	1	1
CO5	3	2	3	3	2	3	1	3	3	3	1	1
CO6	3	2	3	3	2	3	1	3	3	3	1	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS952	**Environmental Sample Analysis**	PCR (Practical)	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA) and Viva-Voce					
CY1152,2152		CT and Viva voce					

Course Outcome (The students will master the following)	• CO1:. The course is designed to give the students a broad understanding of the issues related to the basic concepts and principles of analysis of soil and water quality parameters. • CO2: Students will also accumulate idea about the permissible limit, present concentration etc. of different environmental impurities. • CO3:. Demonstrate an idea about the soil, water and wastewater quality standards and its regulations. • CO4: Students will also accumulate idea about the soil quality status with respect to nutrients like N, P and K present.
Topics Covered	1. *p*H measurement of soil; 2. Estimation of organic carbon content in soil; 3. Chlorine content in drinking water; 4. Estimation of phenol in industrial waste-water sample 5. N, P and K of soil 6. Cyanide in industrial waste-water sample
Text Books, and/or reference material	1. APHA, A, WEF, (1998). Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works Association,Water Pollution Control Federation, Washington DC. 2. Practical Environmental Analysis. Miroslav Radojevic & Vladimir N. Bashkin, Publisher: Royal Society of Chemistry; 2nd edition (April 26, 2006),ISBN-10: 0854046798, ISBN-13: 978-0854046799 3. Practical Manual of wastewater chemistry. Barbara A. Hauser,Publisher: CRC Press, 1st edition (June 1, 1996).ISBN-10: 1575040123 ISBN-13: 978-1575040127.

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	1	3	3	3	2	3
CO2	3	2	3	2	3	2	1	3	3	3	3	3
CO3	3	2	3	3	3	2	1	3	3	3	3	3
CO4	3	3	3	2	3	2	1	3	3	3	3	3

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE931	**Application of some important reactions in synthetic organic chemistry**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					

Course Outcomes	• CO1: Understanding of mechanism of few important reactions, their application in different field of synthetic organic chemistry. • CO2: Uses of strategy of Hydroboration and wittig reaction for carbon-carbon bond formation, reduction of methodology for specific transformation by Birch reduction, how the better yield of product could be obtained, their tactics, strategy and control has been highlighted. • CO3: Role of specific reagents with related mechanism in their transformation and their mechanism from substrate to products is included for their step by step synthesis.
Topics Covered	1. Hydroboration reaction of alkenes, mechanism and hydrolysis process, Regioselectivity, stereoselectivity and Enantioselective hydroboration reaction, Uses of 9-BBN (in Suzuki Cross coupling reaction and others) and Monoisocamphenylborane ($IpcBH_2$), isomerisation of alkenes via hydroboration reactions, Carbon-Nitrogen, Carbon-halogen bond formation, synthesis of cyclopropyl, cyclobutyl derivatives and bicyclo compounds. 10 L 2. Birch Reduction: Mechanism, dependent factors, Application of birch reduction in aminolysis, hydrogenolysis, Wilds & Nelsen modification for pure products in Birch reduction, Regio-selectivity of Birch reduction. Hine postulates; Reduction of substitute benzenoid systems with EWG and EDG; biphenyl systems, regio-selective reduction of naphthalene and substituted naphthalene; Stereo selective of Birch reduction in naphthalene. Reduction of Anthracene and Phenanthrene systems; single electron transfer system (SET), application in natural product synthesis with special emphasis on Gibberalic acid. 10L 3. Wittig reactions or chemistry of Ylide: synthesis of phosphoylide; Stereo-chemical outcome of wittig reactions and their dependent factors. Stereo-selectivity in case of stabilised and non stabilizedylides. Scholar modifications. Effect of ligands in phosphorous ylide. Advantages of Wittig-Horner reaction over Wittig reaction; Difference in reactivity of phosphorous and sulphur ylide; Regio selective and stereoselective reaction with stabilized and non-stabalizes sulphur ylides. 10L
Text Books, and/or reference material	<u>Suggested Text and reference Books:</u> 1. F.A. Carey & R.J. Sundberg, Advanced Organic Chemistry, Springer, 2007 2. K.C. Nicolaou& E.J. Sorensen, Classics in Total Synthesis: Targets, strategies and Methods, Wiley, 1996. 3. W. Carruthers, Modern Methods in Organic Synthesis, Cambridge University Press, 2004. 4. Principles of Organic Synthesis, R.O.C. Norman & J.M. Coxon, Nelson Thrones, 1993, CRC Press. 5. Organic synthesis by M. Smith, Elevier, 4th Edition, 2016. 6. Recent published papers in reputed journals on Hydroboration reaction, Wittig reaction and Birch reduction have to follow as advance study for this elective paper.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	2	3	3	3	1	3	1
CO2	3	3	2	3	2	2	3	2	3	3	1	2
CO3	3	2	3	2	1	3	2	2	2	2	2	1

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE932	Natural Products and Drug Design	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
CYC401	CT+EA

Course Outcome (The students will master the following)	● CO1: Understanding the importance of natural products ● CO2: Learning of the structure, synthesis and uses of different Terpenes ● CO3: Know the chemistry of Steroids in hormones ● CO4: Develop knowledge on the chemical structure, synthesis of different natural pigments ● CO5: Concept generation on rational drug design and drug classification ● CO6: Introduction to drug manufacturing done in pharmaceutical industries ● CO7: Fundamental use of computer in drug design and discovery	
Topics Covered	Terpenes: Structural studies on sesquiterpenes, diterpenes, triterpenes and carotenoids; chemistry of carryophyllene, abietic acid, beta-amyrin, alpha and beta-carotenoids	9 Lec
	Steroids and Prostanoids: Reaction and synthesis of steroids, sources of steroid hormones; diosgenin, hecogenin, etc., structure and synthesis of prostanoids	9 Lec
	Natural Pigments: General methods of isolation, structure elucidation and synthesis of anthocyanins, flavones, flavones, isoflavones, aurone, chalcone, xanthone and their chemical interconversions	9 Lec
	Drug Design: Drug definition, Concepts of LD50 and ED50, introduction to rational approach to drug design, physical and chemical factors associated with biological activities, structure-activity relationship, and mechanism of drug action. Classification of drugs: Based on structure or pharmacological basis with examples. Antineoplastic agents, cardiovascular drugs, local anti-infective drugs, psychoactive drugs, antibiotics (including vancomycin). Industrial synthesis of important drugs. Modelling: Molecular modeling, conformational analysis, qualitative and quantitative structure-activity relationship.	9 Lec

Text Books, and/or reference material	1. Medicinal Chemistry: An introduction By Gareth Thomas (Wiley) 2. Asymmetric Synthesis of Natural products By Ari M P Koskinen (Wiley) 3. Chemistry of Natural products By S B Bhat, B A Nagasampagi, M Sivakumar (Narosa) 4. An Introduction to Medicinal Chemistry by G L Patrick (Oxford)' 5. Bioinformatics and Computational Biology in Drug Discovery and Development by William T. Loging (Cambridge)

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	1	2	1	2	3	3	1	1
CO2	3	1	1	1	1	2	1	3	2	2	2	1
CO3	3	2	1	1	1	3	1	3	3	3	1	1
CO4	3	1	1	1	1	2	1	2	2	3	1	1
CO5	3	3	3	3	3	3	1	3	3	1	3	1
CO6	3	3	3	3	3	3	1	3	3	1	3	1
CO7	3	3	3	3	3	3	3	3	3	1	3	1

Course Code	Title of the course	Program Core (PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYE933	Bioorganic Chemistry	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
CYC401, CYC503	CT+EA
Course Outcome (The students will master the following)	• CO1: Generation of concept on the interdisciplinary interface lies within Chemistry and Biology • CO2: Learn the Chemistry of Nucleic acids (DNA, RNA) • CO3: Develop knowledge on the enzyme chemistry • CO4: Introduction of enzyme inhibitors and inhibition kinetics

Topics Covered	Nucleoside, nucleotides and Nucleic acids: Basic concept and importance; Bio-synthesis of purine and pyrimidine nucleotides, synthesis of adenosine, Guanosine; Nucleotides: synthesis of adenyltlic acid(AMP), Guanylic acid(GMP), uridylic(UMP) acid and cytidilic acid; Cell structure, DNA structure and genetic material, replication and transcription of DNA, RNA and protein synthesis, genetic material and genetic code Enzyme Chemistry: Enzymes: Chemical and biological catalysts. Nomenclature and classification, concept and identification of active sites by use of inhibitors, catalytic power, specificity and regulation. Examples of some typical enzyme mechanisms for chymotripsin, and carboxypeptidase-A. Different types of enzyme catalyzed reactions, Co-enzyme chemistry. Enzyme models: Host-guest chemistry, chiral recognition, molecular asymmetry and prochirality, biomimetic chemistry, crown ether, cryptates, cyclodextrins, calixarin Bioorganic Chemistry: Enzyme kinetics: MichaelisMenten and Lineweaver-Burk plots, reversible and irreversible inhibition. Mechanism of enzyme action: Typical enzyme mechanism for ribonuclease, lysozyme. Chemical models and mimics for enzymes, receptors, peptides, carbohydrates and other bioactive molecules, catalytic antibodies- Design, synthesis and evaluation of enzyme inhibitors. Enzyme catalyzed reactions: Carboxylation and decarboxylation. Isomerization and rearrangement.	8 Lec 12 Lec 12 Lec
Text Books, and/or reference material	1. Principles of Biochemistry by Lehninger 2. Biochemistry by Voet&Voet 3. An Introduction to Medicinal Chemistry by G L Patrick (Oxford)	

Mapping of CO (Course outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	2	2	3	3	1	3	1
CO2	3	3	3	2	3	3	2	3	3	1	2	1
CO3	3	2	2	3	3	3	1	3	3	1	1	1
CO4	3	3	3	3	3	2	2	2	3	2	2	1

<table>
<tr><td colspan="9">Department of Chemistry</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYE934</td><td>Advanced Stereochemistry and structure activity Correlation</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">CYC303</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">

CO1: Learn about the three dimensional structure of organic molecules, which govern their reactivity in different reactions.
CO2: Advance stereochemistry helps to synthesize biological active compounds with better yield and minimum by-products.
CO3: In the field of drug design & drug delivery, insecticides and pesticides, new bio-active molecules could be synthesized for better utility in field of pharmaceutical science, agriculture and material science.
CO4: It helps to understand the basic knowledge in synthesis of organic molecules and to obey the guide lines of green chemistry principle.
CO5: With help of knowledge in stereochemistry and structural correlation, the hurdle in stereochemical problem in industries in large scale production of polymer, drug etc. could be solved.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
1. Advanced stereochemistry: Configarational analysis: Relative and absolute configuration. 2 Lec.
2. Determination of relative configuration:
(i) Chemical correlation not affecting the chiral atom,
(ii) Chemical correlation affecting bonds to the chiral atom in a ‘known way’
(iii) Correlation by asymmetric synthesis: Horeaus rule, Prelog’s rule, Cram’s rule (Felkin modification), and Sharpless rule
(iv) Physical methods: NMR, MS, IR, dipole moment, ORD, CD. 8Lec.
3. Optical rotation and optical rotatory dispersion: Preliminary concept about linearly polarised light (LP), RCP and LCP; circular birefringence; and circular dichroism and optical rotatory dispersion; Cotton effect; ORD of ketones and Octant rule. 8 Lec.
</td></tr>
</table>

	4. Conformation of acyclic and cyclic system (3-8 membered rings), decalin, octalene, and bridged bicyclo systems; stability, reactivity and mechanism, Cortin Hammett principle and Winstein-Eliel equation (special emphasis on 5 and 6 membered rings with and without heteroatoms like O, S and N). 8Lec. 5. Quantitative relationship between structure and reactivity: (i) Liner free energy relation: Hammett equation; Equilibrium and rate in organic reactions; (ii) Separation of polar, steric and resonance: (iii) Taft equation; (iv) Grunwald-Winstein equation. (iv) Some application of structure-reactivity correlation study. 8 Lec.
Text Books, and/or reference material	1. Stereochemistry of Carbon Compounds. Ernest L. Eliel. McGraw-Hill 2. Basic Stereochemistry of Organic Molecules, Oxford University Press: Subrata Sen Gupta 3. Stereochemistry Of Organic Compound; Principle and Applications by D. Nasipuri 4. Stereochemistry. Conformation and Mechanism. P. S. Kalsi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	1	3	2	2	1	2
CO2	3	2	3	2	2	2	2	3	2	2	1	2
CO3	3	2	3	2	2	2	2	3	2	2	1	2
CO4	3	3	3	2	2	3	1	3	2	3	1	2
CO5	3	3	3	2	2	3	2	3	2	3	1	2

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS953	**Multi Step Synthesis and characterization of Organic Compounds**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA) and Viva-Voce)					
CYS653		CT AND Viva-Voce					

Course Outcomes	• CO1: To reach a targeted product through multiple reaction process using suitable reagents and optimum reaction conditions. • CO2: To learn Separation and Purification of products • CO3: To learn Purification techniques, like phase transfer, crystallization, GC-Mass and other spectroscopic method will be adopted • CO4: To Learn Understand the basic concept behind separation process for most common spectroscopic method like; UV-Vis, FT-IR, NMR, ESI-Mass and GC-Mass. • CO5: To learn how to reach a maximum yield with minimum uses of solvent, reagents and energy like; heat and electricity (Green chemistry).
Topics Covered	1. Oxidation of Benzoin to benzil followed by rearrangement to benzilic acid 2. Preparation ofbenzophenoneoxime followed by rearrangement tobenzanilide 3. Preparation of1,3,5tribromobenzenefrom 2,4,6- tribromoaniline via diazotization 4. Preparation ofdiethyl adipatefrom Cyclohexanol followed by Dickmann cyclisation to 2-carboethoxy cyclopentanone 5. Preparation of *p*-nitro aniline from acetanilide
Text Books, and/or reference material	1. Vogel's Textbook of practical organic chemistry 2. Advanced practical chemistry : Subas C. Das 3. An Advanced Curse in Practical Chemistry: Nad, Mahapatra and Ghoshal

OPEN ELECTIVE COURSE BASKETS
THE STUDENT CAN OPT ANY OPEN ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER, EXCEPT THE SUBJECT(S) WITH HIS/ HER OWN DEPARTMENT CODE.

Basket– 1 (4th Semester)

Basket– 2 (5th Semester)

Basket– 3 (7th Semester)

Basket– 4 (8^{th} Semester)

Basket– 5 (8^{th} Semester)

BASKET – 1

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO440	Media, Culture and Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1 Understanding key issues in Media Studies in international perspective • CO2 Analyzing theoretical concepts in sociocultural contexts and exploring practical aspects						
Topics Covered	1. Introduction to Media Studies: Basic Theories and Concepts (4) 2. Use of Technology in Media Studies: Issues and Perspectives (4) 3. Approaches to Cultural Studies in Understanding Media and Society (4) 4. Visual Media: Images and Implications (4) 5. Popular Culture and Impact of Cinema (6) 6. Myths and Stereotypes in Media Representations (2) 7. Deconstructing Orientalism in Media (2) 8. Transnationalism and Cosmopolitanism in Media Studies (4) 9. Globalization and Gender Issues in Media (4) 10. Folk Media and its Impact (4) 11. Mass Media and Development Communication (2) 12. Emergence of New Media and Cyber Culture (2)						
Text Books, and/or reference material	Recommended Readings: 1. Dasgupta, S., Sinha, D. Chakravarti, S. (2011). *Media, gender and popular culture in India: Tracking change and continuity*. Thousand Oaks, Calif. : Sage Publications 2. Durham, M. G., & Kellner, D. M. (Eds.). (2009). *Media and cultural studies: KeyWorks*. Massachusetts: Blackwell Publishers. 3. Graham, M. *"Threshold of the Information Age: Radio, Television, and Motion Pictures Mobilize the Nation," in A. Chandler & J. Cortada eds. A Nation Transformed By Information. 2003.* 4. Rai, M. & Cottle, S. "Global Mediations. On the Changing Ecology of Satellite Television News," Global Media and Communication. Vol. 3 (1), April 2007. 5. Gitlin, T. "Media Sociology: The Dominant Paradigm" Theory and Society, Vol. 6, No. 2 (Sep., 1978), pp. 205-253.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	-	-	3	2	-	3
CO2	-	-	-	-	-	2	-	-	3	2	-	3

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAO441</td><td>Discrete Mathematics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid-term assessment (MA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Set Theory</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To enable the students to apply the basic concept of Logic to solve engineering and Artificial Intelligence related problems.
• CO2: To enable the students to solve problems of combinatorics.
• CO3: Students will have knowledge of Graph Theory which arises in many engineering and physical problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to set theory; combination of sets; power sets; finite and infinite sets, Introduction to Combinatorics, Counting techniques, The inclusion-exclusion principle, The pigeon-hole principle and its applications, Recurrence relation, Generating function, Partial order relations; POSETS. [6]
Mathematical logic, Predicate logic, Basic logical operation, Truth tables, Logic proposition and proof, Notion of interpretation, Method of proofs, Validity, consistency and completeness. [6]
Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates, Different forms of the principle of mathematical induction. [5]
Relations, Equivalence relation and equivalence classes, Diagraphs, Computer representation of relations, Warshall's algorithm, Representations of relations by binary matrices and digraphs; operations on relations. Closure of a relations; reflexive, symmetric and transitive closures. [7]
Lattice Theory and Introduction to Boolean algebra and Boolean functions, Different representations of Boolean functions, Application of Boolean functions to synthesis of circuits, Composition of function, functions for computer Science, Permutation function and growth of functions. [5]
Introduction of discrete numeric functions, Asymptotic behavior, Generating functions, Linear recurrence relations with constant coefficients (homogeneous and non-homogeneous cases), Solution of linear recurrence relations using generating functions. [5]
Path, cycles, Handshaking theorem, Bipartite graphs, Sub-graphs, Graph isomorphism, Operations on graphs, Eulerian graphs and Hamiltonian graphs, Planar graphs, Euler formula, Traveling salesman problem, Shortest path algorithms, Minimum spanning tree algorithms, Maximum flow algorithms. [7]</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. Discrete Mathematics and its Applications - Kenneth H. Rosen 7th Edition -Tata McGraw Hill Publishers – 2007. 2. Elements of Discrete Mathematics, C. L Liu, McGraw-Hill Inc, 1985. Applied Combinatorics, Alan Tucker, 2007. **Reference Books:** 1. Concrete Mathematics, Ronald Graham, Donald Knuth, and Oren Patashnik, 2nd Edition - Pearson Education Publishers - 1996. 2. Combinatorics: Topics, Techniques, Algorithms by Peter J. Cameron, Cambridge University Press, 1994 (reprinted 1996). Topics in Algebra, I.N. Herstein, Wiley, 1975.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAO441	CO1	3	3	3	2	3	2	1	-	-	-	1	2
	CO2	3	2	3	3	2	1	1	-	1	-	1	1
	CO3	3	3	2	3	2	2	2	1	-	1	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAO442</td><td>Probability and Stochastic Processes</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Knowledge of differential and integral calculus, basics of probability at MAC02</td></tr>
<tr><td colspan="3"></td><td colspan="5"></td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">• CO1: To provide the basics of probability theory.
• CO2: Introduce to students the probability models in physics, engineering, biology etc.
• CO3: To highlight the roles of stochastic processes in physics, social science, finance etc.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Introduction: Axiomatic definition of Probability, Conditional Probability and Multiplication Rules, Stochastic independence, Baye's theorem and applications. (8)
Random Variables & Probability Distribution: Random variables: Discrete and continuous, discrete and continuous probability distributions, Binomial and Poisson distribution, Normal distribution, Exponential distribution, Joint probability distributions, bivariate normal distribution. (6)
Mathematical Expectation: Expectation of random variable, Properties of</td></tr>
</table>

	Expectation, Variance and covariance of random variables, Means and variances of Linear Combinations of Random Variables, Conditional Expectations. Correlation coefficient. (6) **Functions of Random Variable**: Transformation of Variables, Moments and Moment Generating Functions, Characteristics functions, Normal Approximation to Binomial. (6) **Stochastic Processes:** Stochastic Process: definition and examples, Stationary Processes, Auto correlation, Auto Covariance, cross correlative coefficient, Martingales. (6) **Markov Chains**: Definitions and examples of Markov chains, Chapman-Kolmogorov Equations & classification of states, Ergodic Markov Chain, Applications of Markov chains, Time reversible Markov chains. (6) **Poisson Process**: Poisson Process, Inter-arrival & waiting time distributions, Non-homogeneous Poisson Process, Conditional Poisson process. (4)
Text Books, and/or reference material	**Text Books:** 1. T. Veerarajan: Probability, Statistics and Random Process, Tata McGraw-Hill Education, 2002. 2. Ronald E Walpole and Raymond H Myers: Probability and Statistics for Engineers and Scientists 3. J. Medhi, Stochastic Process, Wiley Eastern Limited, Second Edition, 1994. **Reference Book:** 1. C. Grinstead and J. Snell, Introduction to probability, American Mathematical Society, 1997. 2. Roy D Yates and David J. Goodman, Probability and stochastic processes, John Wiley and Sons, 1998.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO442	CO 1	3	3	3	3	2	1	-	1	1	1	1	1
	CO 2	3	3	3	3	3	-	-	-	-	-	-	-
	CO 3	3	3	3	3	3	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO441	**Quantitative Biology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes		CO1: To see living systems from the perspective of engineering, physics, mathematics and computer science.					

	CO2: To understand systems based approaches in biological sciences. CO3: To use web-based resources that will help them in modeling complex biological processes. CO4: To choose an appropriate modeling technique for a complex biological system
Topics Covered	**Introduction to Nonlinear Phenomena** One-dimensional systems and elementary bifurcations, Two-dimensional systems; phase plane analysis, limit cycles, Nonlinear Oscillators, qualitative and approximate asymptotic techniques, Hopf bifurcations, chaos, strange attractors and fractals. [12] **Biological Networks and Motifs** Basic concepts in networks and chemical reactions. Input function of a gene, Michaelis-Menten kinetics, and cooperativity, Autoregulation, feedback and bistability, Introduction to synthetic biology and stability analysis in the toggle switch, Oscillatory genetic networks, Feed-forward loop network motif. [9] **Stochastic Modeling of Biological Systems** Concept of probability, Introduction to stochastic gene expression, Causes and consequences of stochastic gene expression, Markov processes and Markov Models, Stochastic modeling—The master equation, Fokker-Planck Equation, and the Gillespie algorithm, Survival in fluctuating environments, Robustness in development and pattern formation. [12] **Population Dynamics & evolutionary games** Interspecies interactions, the Lotka-Volterra model, and predator-prey oscillations, Ecosystem stability, critical transitions, and the maintenance of biodiversity, Infectious disease spread: SIR and other models, Introduction to microbial evolution experiments, and optimal gene circuit design, Fitness landscapes, Evolutionary games. [9]
Text Books, and/or reference material	**TEXT BOOKS:** **1.** Alon, Uri. *An Introduction to Systems Biology: Design Principles of Biological Circuits*. Chapman & Hall / CRC, 2006. ISBN: 9781584886426. **2.** Strogatz, Steven H. *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*. Westview Press, 2014. ISBN: 9780813349107. **3.** Network Science, A-L. Barabasi, Cambridge University Press **REFERENCE BOOKS:** **1.** Nowak, M. A. *Evolutionary Dynamics: Exploring the Equations of Life*. Belknap Press, 2006. ISBN: 9780674023383. **2.** Alberts, Bruce. *Essential Cell Biology*. Garland Science, 2009. ISBN: 9780815341291.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
PHO 441	CO1	3	2	2	1			2					1
	CO2	3	2	2	2			2					1
	CO3	3	2	2	3	3	2	1		1	1	1	1
	CO4	3	2	2	3	2	2	1	1	1			1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO 441</td><td>FOOD BIOTECHNOLOGY</td><td>PER/OER</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To quantitate and identify the spoilage microorganisms present in food.
CO2: To learn the concepts of food fermentation and increase the shelf life of food.
CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach.
CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness.
CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Food Microbiology: [8]
Microorganism in food, Intrinsic and extrinsic parameters of food, rapid methods for identification of microorganism in food, Food borne illness, Biosensors –use and application
Food preservation [8]
Pasteurization, sterilization, Canning, thermal process of food with numericals, Irradiation, Dehydration, low temperature , use of preservatives
Food fermentation [10]
Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages, dairy product, non-beverage product , use of genetic engineering techniques for improved quality product.
Genetically modified food [8]
Fruit ripening, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Ethical and regulatory issues
Biotechnology in relation to food product [4]
Antioxidant, nutraceutical,
Food safety [6]
Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series, detection of toxin, heavy metal , pesticide and herbicides</td></tr>
</table>

Text Books, and/or reference material	Suggested Text Books: Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Suggested Reference Books: Fundamentals of Food Biotechnology by Lee

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	2	1	1	2	3
CO2	3	3	3	3	2	2	3	2	1	1	2	3
CO3	3	3	3	3	3	3	3	3	2	1	2	3
CO4	3	2	3	3	1	3	3	2	2	1	1	3
CO5	3	2	2	2	3	3	3	3	3	3	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO440	**Introduction to Earthquake Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	• CO1: Applying Engineering mathematics in solving vibration problem • CO2: Ability to design a building earthquake resistive • CO3: Learn basic of Earthquake engineering • CO4: Ability to manage disaster						
Topics Covered	**Seismology:** Engineering geology of earthquakes, plate tectonics, Seismicity of the world, Seismic waves, faults, plate boundaries, Intensity, Strong ground motion, Measuring of Earthquake, Earthquake Magnitude-Local (Richter) magnitude, surface wave magnitude, Moment magnitude. Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement, Frequency Content and duration. **(12)** **Elementary Vibration:** Vibration of elementary system, Single degree and two-degree freedom systems, Earthquake analysis, Response spectrum concept **(10)** **Earthquake Resistant Design:** Philosophy, Code based methods for seismic design for RC buildings. Behaviour of masonry structure during earthquake, bands & reinforcement in masonry **(10)** **General Guidelines**: Efficient seismic resistant planning, selection of sites, importance of architectural features in earthquake resistant buildings,						

	continuity of construction, projection special construction features like pounding, floating column, soft storey, stair case etc., role of engineers in the earth quake mitigations & disaster management **(10)**
Text Books, and/or reference material	***Text Books:*** 1. Earthquake resistant design of structures by Pankaj Agarwal and Manish Shrikhande 2. Basics of Structural dynamics and aseismic Design by S. R. Damodarasamy and S. Kavitha ***Reference Books:*** 3. Elements of Earthquake Engineering by Jai Krishna, A.R. Chandrasekharan, Brijesh Chandra

Mapping of Course Outcomes Cos→POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	1	-	3	-	-	-	-	-	-	-	-	-
CO3	1	-	-	-	-	2	-	-	-	-	-	-
CO4	-	-	-	-	-	--	-	-	3	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO441	**Elementary Civil Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	· CO1: Gain knowledge about elementary level civil engineering · CO2: To learn the use of survey instruments · CO3: To learn about construction materials and technology						
Topics Covered	**Measurement:** Measurement of lengths, heights, and angles using surveying equipments, chain, tape, Dumpy level, staffs, Theodolites. **(10)** **Survey:** Different mapping methods, elements of chain surveying, compass surveying, plane table surveying, theodolite surveying, leveling and contouring. **(10)** **Building Materials:** Common building materials, stone, brick, timbers, cement, concrete, lime concrete, their strength, characteristics and different types of each material. **(10)** **Construction:** Elements of residential buildings, method of construction, miscellaneous temporary constructions, form work, timbering etc. **(12)**						

Text Books, and/or reference material	***Text Books:*** 1. Surveying and Levelling Part I by T. P. Kanetkar, and S. V. Kulkarni, Pune Vidyarthi Griha Prakashan Pune – 30, 1979 2. Engineering Materials by S. C. Rangwala, Charotar Pub. House, Anand 3. Building Construction by S. C. Rangwala, Charotar Pub. House, Anand ***Reference Books:*** 4. Building Construction by B. C. Punmia, A. K. Jain and A. K. Jain, Laxmi Publications (P) Ltd.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	-	-	-	-	-	-	-	-	-	-	3	-
CO2	-	-	-	-	-	-	-	-	-	-	3	-
CO3	-	-	-	-	-	-	-	-	-	-	3	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO442	**Experimental methods and Analysis**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Basic Engineering, statistics & probability		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs):	· CO1: Development of skills for predicting engineering system behaviour · CO2: Knowledge of basics of data analysis for further applications. · CO3: Developing the requisite skill that helps in the advanced courses related to experimental study						
Topics Covered (Hrs)	**Types of measurements and errors**: Internal & external estimates of errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Best estimate of true value & precision, Methods of calculating best estimate of true value & standard deviation **(7)** **Combination of measurements**: Accuracy of mean, Significant digits. Method of least squares & its application for calculation of best estimate of true value, curve fitting, **(8)** **General linear regression**: Comparison & combination of measurements. Extensions of least square method. Theory of errors, Binomial & Gaussian distribution, Confidence limits, Significance test, principle of maximum likelihood & goodness of fit, Chi-square test. **(9)** **Displacement measurement**: Dial Gauge, Microcator, Optical Method, Pneumatic Transducer, Strain Gauges, Variable Inductance & Capacitance Transducer, Piezo-Electric, Electro-Kinetic, Photo-Electric, Ionization, Vibrating Wire & Vacuum Tube Transducer. **Force & Torque:** Elastic Type, Fluid Load Cell, Dynamometers. **Temperature:** Bi-Materials, Pressure & Resistance Thermometers,						

	Thermocouples & Pyrometers. **Pressure:** McLeod Gauge, Pirani Gauge, Ionization Gauge, Manometers, Bourdon Tube, Resistance Gauges. **Fluid Velocity:** Pitot tube & Hot Wire Anemometer, LDA. Flow Measurement in Confined Passages & Open Channels. Miscellaneous measurements **(10)** **Dynamic Response** of a Measuring Instrument, Response to Transient & Periodic Signals, First & Second order systems as well as their Dynamic Response Characteristics. (**8)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Instrumentation, Measurement and Analysis by B C Nakra and K K Chaudhary, Tata McGraw Hill, 1985. 2. Principles of Measurement, Precision, Error and Truth by N C Barford, Addison Wesley, 1967. ***Reference Books:*** 3. Physical Measurement and Analysis by N N Cook and E Rabinowicz, Addison Wesley, 1963 4. Experimental Methods for Engineers by J P Holman and W J Gajda, McGraw Hill Co., 1978

Mapping of Course Outcomes COsàPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	-	-	1	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO441	**PROCESS HEAT TRANSFER**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Nil		CT+MT+EA					
Course Outcomes	• CO1: Illustrate principles and laws of heat transfer of different heat exchanging phenomena • CO2**:** Solve heat transfer problems of different difficulty levels • CO3**:** Design and analyze heat transfer equipment						
Topics Covered	**Module I:** Mechanism of heat transmission: Conduction, Convection and Radiation. Conduction: Fourier's law; Steady-state heat transfer through composite slabs, cylinders and spheres; Optimum thickness of insulation; Unsteady-state heat transfer - use of Gurnie-Lurie chart, one and two-dimensional conduction in different geometry. [14 hrs.] **Module II:** Convection: Forced convection; Thermal boundary layer; Analogy between heat						

	and momentum transfer; Dimensional analysis of heat transfer; Heat transfer coefficients; Log-mean temperature difference; General equation for forced convection; Equivalent diameter; Natural convection; Condensation; Boiling of liquids. [10 hrs.] **Module III:** Radiation: Black body and Gray body; Laws of radiation; View factor; Radiant heat exchange between surfaces; Radiation from flame, gases and vapors. [7 hrs.] **Module IV:** Heat exchangers: Type of different heat exchangers and their design - Double pipe, Shell and tube, finned tube and Compact heat exchangers; Condensers and reboilers. **Evaporation:** Type of evaporators with accessories; Capacity and Steam economy; Boiling point rise/elevation; multiple effect evaporators; Design of single and multiple effect evaporators. [17 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Heat Transfer : Principles and Applications – Binay K. Dutta (Prentice-Hall India) 2. Process Heat Transfer – D. Q. Kern (McGraw-Hill) 3. A Text Book on Heat Transfer – S P Sukhatme (Universities Press) Suggested Reference Books: **1.** Heat Transmission – Mc Adams (McGraw-Hill)

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	1	2	2	-	-	-	-	-	-	-	-
CO3	-	-	3	-	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 441	Data Structures and Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC-01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding the fundamental concepts of data, data types and abstract data types. • CO2: Implementation of different abstract data types using different data structures. • CO3: Design and development of algorithms for real-life applications. • CO4: Apply different types of data structures to implement different						

	algorithms.
Topics Covered	Introduction to problem solving through computer, Design of algorithm to solve a problem, Concept of static and dynamic memory allocation, Algorithms and data structures, Concept of Abstract Data Type (ADT) with examples. (4L) Efficiency of an algorithm, Time and space complexities, Impact of data structure on the performance of an algorithm. (3L) Array, Single and multi-dimensional array, Memory representation (row major and column major) of array, Insertion, and deletions in array, Advantages and disadvantages of array. (3L) Linked list as an ADT, Memory allocation and deallocation for a linked list, Linked list versus arrays, Types of linked lists: singly linked list, doubly linked list, circular linked list, Operations on linked list: creation, display, insertion and deletion (in different positions). (5L) Stack as an ADT, Main operations (push and pop), auxiliary operations and axioms, Array implementation of stack, Limitation of array implementation, Linked list implementation of stack, Applications of stack: Recursion, Function call, Evaluation of postfix expression using stack. Conversion from infix expression to its postfix version. (5L) Queue as an ADT, Main operations (enqueue and dequeue), Auxiliary operations and axioms, Array implementation of queue, Limitation of array implementation and Circular queue, Linked list implementation of queue, Priority queue and its applications. (4L) Trees, Definition and mathematical properties, Binary trees, Representation of binary trees in memory: linked representation, array representation, Binary tree traversal, Pre-order, Inorder, Post order, Expression trees, Heap and its applications, Search trees: Binary search trees, Balanced binary search trees. (8L) Searching and sorting: Linear search and binary search, Bubble, selection, insertion, Quick sort, Merge sort, Heap sort, Radix sort. (8L) Graphs: Mathematical Properties, Degree, Connectedness, Memory representation of graph: adjacency matrix, Adjacency list, Directed Graphs, Directed Acyclic Graph. (2L)
Text Books, and/or reference material	**Text Books:** 1. Lipschutz, "Data Structures (Schaum's Outline Series)", Tata Mcgraw Hill. 2. E. Horowitz, S. Sahni, S. Anderson-Freed, "Fundamentals of Data Structures in C", Universities Press; Second edition (2008). **Reference Books:** 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	1	1	1	1	2	2	1
CO2	3	2	3	1	2	1	1	1	1	2	2	1
CO3	2	3	3	1	2	1	1	1	3	2	3	1
CO4	2	3	3	1	2	1	1	1	3	2	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 442	Object Oriented Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSO442 (Object Oriented Technology)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding of Object Oriented Design Approach and its real world applications • CO2: Analyzing problems in terms of object oriented methodologies. • CO3: Implement programs using concepts of classes and objects. • CO4: Specify the forms of inheritance and use them in problem solving. • CO5: Learn and implement different forms of polymorphism. • CO6: Developing skills to write generic codes						
Topics Covered	Introduction to problem solving through computer, Design of algorithm to solve a problem, Concepts of functions, loops, strings, arrays, pointers, structures etc. Procedure Oriented Programming, Object Oriented Programming, Objects and Classes, 3 basic features of OOP, Comparison of procedural programming and object oriented programming, C++ language, cout, cin operator, return type of main, structure of a C++ program, example with description, Tokens, keywords, identifiers, declaration of variables, dynamic initialization of variables, reference variables, scope resolution operator, difference between C and C++. Examples and Practice Sessions. (7L) Declaration of classes and objects, member functions, accessing class members, inline function, Nesting of member function, Private member function, Static data members, static member function, Objects as function argument, Friend functions, structure and class, returning objects, Examples and Exercises. (5L) Overview of constructors, default constructors, parameterized constructors, constructors with default arguments, dynamic initialization of objects, copy constructors, dynamic constructors & destructors, constraints on constructors & destructors. Examples and Exercises. (4L) Operator overloading overview, defining operator overloading function, Overloading unary operator, binary operators and arithmetic operators, Overloading using friend function, multiple overloading, Overloading comparison operators, conversion between objects and basic types, conversion between objects of different classes, overloading various operators, such as +, -, *, /, =, ==, (), [], {}, &&, ||, ++ (preincrement and post increment) etc. Examples and Exercises. (6L) Overview, defining derived classes, types of inheritance, single inheritance, making private member inheritable, multilevel inheritance, Multiple inheritance, ambiguity in multiple inheritance Hierarchical inheritance,hybrid inheritance, Virtual base classes, abstract classes, Constructors in derived classes, initialisation list, nesting of classes, Examples and Exercises. (7L) Overview, late binding, early binding, Pointers to objects, accessing class members using pointers, creating objects at runtime, This pointer, pointers to derived classes, virtual functions, pure virtual functions, Examples and Exercises. (5L) Overview of Templates, generic class, function template, function template with multiple argument, Class template, Class template with multiple						

	argument, overloading template function, templates as member function of a class, Examples and Exercises. (3L) Exception handling overview, exception handling mechanism, throwing and catching mechanism, Multiple catch, catch All exceptions, rethrowing an exception, Examples and Exercises. (3L) Mini Project Implementation using the concepts. (2L)
Text Books, and/or reference material	**Text Books:** 1. E Balagurusamy, "Object oriented programming in C++", Mc Graw Hill, ISBN 978-93-5260-779-0. 2. Herbert Schildt, "Teach yourself C++", Mc Graw Hill, 3rd Edition, ISBN 0-07-882311-0. 3. Herbert Schildt, "C++: The Complete Reference", Mc Graw Hill, 4th Edition, ISBN 0-07-212124-6. **Reference Books:** 1. Stroustrup, "The C++ Programming Language", 3rd Edition, 2002,Addison Wesley. 2. Eckel, "Thinking in C++", Vol1, 2nd Edition, 2002, Pearson. 3. R. Lafore, "Object Oriented Programming with C++", 4th Edition, 2008, Pearson.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	1	3	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	1
CO5	1	2	2	3	3	1	-	-	-	1	3	1
CO6	-	-	3	-	3	3	2	-	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO440</td><td>Digital Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
(Continuous (CT), Mid-Term (MT), End Assessment (EA))</td></tr>
<tr><td colspan="2">Electronic Devices and Circuits I (ECC302), Basic Electronics (ECC01)</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand rules of Boolean Algebra and use it for logic synthesis.
• CO2: Design logic circuits using switches, transistors and integrated circuit building blocks.
• CO3: Understand binary number system and design corresponding arithmetic circuits.
• CO4: Explain and implement A/D and D/A converters.
• CO5: Learn sequential circuit building blocks and implement Finite State Machines.
• CO6: Understand principles of Error Detection and Correction codes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: (L- 1)
Introduction: Definition of Analog & Digital information. Characteristics of Digital Circuits. Advantages of Digital systems.</td></tr>
</table>

	Module 2: (L-2) Boolean Algebra: Introduction – rules of Boolean Algebra, axioms, D´Morgan's theorems **Module 3: (L-4)** Logic Gates: Basic Gates, Universal Gates, Realization of logic gates using switches, Transistors (MOS and BJT) as switch. **Module 4: (L-5)** Logic Synthesis: Two level synthesis, SOP/POS forms, canonical forms; Minimization of logical function by - i) Algebraic method, ii)Karnaugh Map method and iii) Quine Mccluskey Method. **Module 5: (L-6)** Combinational Circuits: Multiplexer, Demultiplexer, Decoder, Encoder, decoder driver, designing using these combinational circuits and their applications. **Module 6: (L-4)** Digital Arithmetic: Number systems, Binary arithmetic, Representing negative numbers – sign-magnitude, 1's complement and 2's complement representations; Arithmatic circuits - Half Adder and Full adder Circuits, multi-bit ripple-carry adder and subtractor circuits. Realization of these circuits using Multiplexers. **Module 7: (L- 6)** Sequential Circuits: Definition, Elements of sequential circuits - Latches and Registers, Different kinds of flip-flops – R-S, J-K, Master-slave arrangement, D, and T type registers; Finite state machines - Moore and Mealy machines; Typical sequential circuits -counters, shift registers and sequence generator; synchronous and asynchronous circuits. **Module 8: (L-4)** Multivibrator: Definition of different types of Multivibrators, their realization by logic gates, op-amp and transistors. 555 Timer IC. **Module 9: (L-3)** A/D & D/A Converter: Different types of D/A & A/D Converters. **Module 10: (L- 3)** Codes and Code converters: Gray code, Excess-3 code, BCD Code, BCD to 7-segment decoder: Error Detection and Correction codes - error detection by parity checking, Principle of error correction, Hamming code. **Module 11: (L- 4)** Different logic families such as RTL, DCTL, DTL, HTL, TTL, ECL, MOS & CMOS logic family their importance and applications.
Text Books, and/or reference material	**Text Books**: 1. M. Morris Mano, Digital Design, 3rd Edition, Prentice Hall of India Pvt. Ltd., 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003. 2. Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2004. **Reference Books**: 1. John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002. 2. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982. 3. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2005. 4. Donald D. Givone, Digital Principles and Design, TMH, 2016. 5. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

COURSE ARTICULATION MATRIX

PO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**
CO#1	3	3	2	2	1	-	-	-	-	-	-	3
CO#2	2	3	3	3	2	-	-	-	-	-	-	2

CO#3	2	3	3	3	3	-	-	-	-	-	-	3
CO#4	2	3	3	3	3	-	-	-	-	-	-	2
CO#5	3	3	3	2	3	-	-	-	-	-	-	3
CO#6	1	2	3	1	1	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO441</td><td>Communication Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods
Continuous (CT), Mid-Term (MT), End Assessment (EA)</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">The assessment methods comprise of quizzes, multiple choice type questions involving real world examples, and subjective questions all either designed in google form or assessed through pen and paper.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Identify the methods of communications.
• CO2: Analyze the methods of communications.
• CO3: Apply wired or wireless communication in proper context.
• CO4: Demonstrate the use of communication in different industrial scenarios.
• CO5: Recognize the current technology trends in communication engineering.
• CO6: Design future communication systems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basics of communication engineering. (2L)
Elements of a communication system; Evolution of communication systems; Challenges and limitations of communication systems; Wired, wireless and storage channels.
Wired communication. (8L)
Telephone: Base and handset, Dialling and signalling, Subscriber loop; Analog and Digital Signals; Sampling: Nyquist's theorem, Aliasing, Time division multiplexing; PCM: Generation, Regenerative transmission, Detection; Line coding: Types, Criterions for choosing a line code; Fiber optics: Elements, Propagation modes.
Wireless communication. (8L)
Requirement of modulation; Analog modulation: AM, FM; Digital modulation: ASK, PSK, FSK; Cellular: Architecture, Generations; WiFi; Satellite: Kepler's laws, Components of satellite communication.
Information theory and coding. (8L)
Information: Definition and measurement, Entropy, Information rate; Source coding: Huffman coding, Channel coding: Hamming code, Cryptography: RSA algorithm.
New frontiers in communication. (8L)
Molecular communication; In-vivo communication; Underground communication;
Underwater communication; V2X communication; IoT.
Industrial communication. (8L)
Serial communication, Fieldbus, HART.</td></tr>
</table>

Text Books, and/or reference material	**Text Books**: 1. Communication Systems - A. B. Carlson. **Reference Books**: 1. Communication Systems – S. Haykin. 2. Modern Digital and Analog Communication Systems - B. P. Lathi.

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	2	1	1	1	1	1	1	1	1	1
CO#2	2	3	3	2	1	1	2	1	1	1	1	2
CO#3	3	2	3	2	1	1	2	1	1	1	1	1
CO#4	2	1	1	3	2	3	1	2	1	1	2	1
CO#5	1	1	1	2	1	2	1	1	2	1	2	1
CO#6	1	1	1	1	1	3	2	1	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO440	FUNDAMENTALS OF POWER SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Nil		CT+MT+EA					
Course Outcomes	• CO1: Given Specification leads to design of network, choice of optimal Voltage, Transmission line and its material. • CO2: Given Specification leads to study of suitable system parameters and in corporation laws of Power systems to choose the most applicable. • CO3: Given Specification emphasizes on the different Tariff structures, by which one can able to judge, compare and select a suitable Tariff plan. • CO4: Given Specification facilitates the design of equipment's on the basis of power factor. • CO5: Given specification will give knowledge about the different types of faults and its severity, which can help to design the protection schemes for those faults.						
Topics Covered	Power System Network: Single phase transmission, three phase transmission, complex power, Basic Structure of power system, overhead and underground systems, overhead line conductors, Transmission, and distribution systems in India. (2) Generating Stations: Steam Power station, Hydro-electric power station, Gas turbine power station, nuclear power station, classification, Comparison of various power stations. (5) Supply Systems: AC power supply scheme, Comparison of DC and AC transmission, Advantages of High transmission voltage, various systems of						

	power transmission, comparison of conductor material in overhead system, comparison of conductor material in underground system, Choice of transmission voltage. (5) Line Parameters and Performance of Transmission Lines: Line resistance, Inductance, Capacitance, Representation of Lines, per unit method, advantages of per unit systems, short transmission line, medium length transmission line, long transmission line, Evaluation of ABCD parameter, equivalent pi and T circuit. (8) Conductors: Introduction, Type of Conductor, Skin effect, Kelvin's economy law, modified Kelvin's law, Limitations of Kelvin's law (4) Overhead Line Insulators: Type of insulator, voltage distribution over insulator string. (3) Tariffs: Introduction, Types of Tariff-Flat demand tariff, straight line meter rate tariff, Block meter type tariff, Two-part tariff, Power factor tariff, Peak load tariff, three-part tariff (3) Power Factor Improvement: Introduction, Disadvantages of low power factor, causes of low power factor, power factor improvement, power factor correction by static capacitor. Economics of power factor improvement. (5) Power Systems Fault and Protection: Symmetrical components, Symmetrical faults and unsymmetrical faults, Switches, fuses, circuit breakers, protective systems, protective relays, (5) Power System Earthing: Type and methods of earthing, earth resistance, Design of Earthing grid, Tower footing resistance, measurement of earth resistance, neutral grounding. (2)
Textbooks, and/or reference material	Textbooks: 1. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Hodder Arnold 2. A. R. Bergen, V. Vittal, Power Systems Analysis, Pearson Edition Reference Books: 1. John J. Grainger & William D. Stevenson, Power system analysis, Tata McGraw Hill Education. 2. D. P. Kothari & I. J. Nagrath, Power System Analysis, Tata McGraw Hill

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	1	1		1			1
CO2	3	3	2	1	1	1			1			
CO3	3	1	3	1	2	3		1				2
CO4	3	3	2	1	2	2	1		1			1
CO5	3	3	2	1	2	1	1	1	1		1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO441	CONCEPT OF INDUSTRIAL ELECTRONICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
ECC 331 (ANALOG ELECTRONICS), EEC 403(DIGITAL ELECTRONICS)		CT+MT+EA					
Course Outcomes	• CO 1: Acquire an idea about semiconductor devices • CO2: To learn the basic operation of the ac-dc/ dc-dc/ dc-ac/ ac-ac components • CO3: To identify the application of the components in different fields of Engineering • CO4: To identify the utilisation of the components in Industry						
Topics Covered	Review of Power Electronic Systems: Overview of Some Modern Power Semiconductor Devices. (2) Digital Electronics: Overview, Number Systems, Integrated Circuits, Logic Families, Pin Identification. (6) Uncontrolled rectifiers: Single phase and multiphase different circuit arrangements and their operation, analysis, performance evaluations. (6) Controlled rectifier: Semi Controlled and fully controlled converters, single phase and multiphase, different circuit arrangements and their operation analysis performance evaluations. (6) DC-DC Converters: Classification, principles of operation, step down (Buck) and step up (Boost) switched mode power supply, Buck-Boost Converter. (6) Inverters: Classification, theory of operation, square wave Inverter, PWM switching topology, performance evaluation, applications. (6) Applications: DC Drives, AC Drives, Power Conditioners and Uninterruptible Power Supplies, Power Line Disturbances, Power Conditioners, UPS. (6) Other Residential and Industrial Applications. (4)						
Textbooks, and/or reference material	Textbooks: 1. B. K. Bose, Power Electronics and AC Drives, Prentice- Hall 2. N. Mohan, T. M. Underland & Riobbins, Power Electronics: Converters, Applications & Design, John-Wiley. Reference Books: 1. L. Umanand, Power Electronics, Essentials & Applications, Wiley India Pvt. Ltd						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1	PO12
CO1	3	3	3	3	3	3	3	2	2	2	1	3
CO2	3	3	3	3	3	3	3	2	2	1	2	2
CO3	3	3	3	3	3	3	3	2	2	1	2	2
CO4	3	3	3	3	3	3	3	2	2	1	2	2
CO5	3	3	3	3	3	3	3	2	2	2	1	3
CO6	3	3	3	3	3	3	3	2	2	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Electrical Engineering</th></tr>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>EEO442</td><td>ENERGY CONSERVATION, AUDIT AND ICT & IOT APPLICATION FOR MONITORING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO 1: To understand the Overall Energy Scenario (National & International
• CO2: To build the skill in Energy management
• CO3: To be able to conduct the energy audit.
• CO4: To understand the energy saving
• CO5 :To understand the energy monitoring through ICT & IoT</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Overall understanding Energy Scenario National and International perspective, Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification, relative merits and demerits, Carbon emission, carbon credit, International environmental meet for awareness of Green House emission (GHG). (10)
Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy. (6)
Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Energy performance, Matching energy usage to requirements, maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. (6)
Procedures and Techniques for Energy Audit, Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering. Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation. (8)
Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. Energy Audit Reporting: The plant energy study report-Importance, contents, effective organization, report writing and presentation. (6)
Basics of Information Communication Technology (ICT), Internet of Things (IoT). Basic sensors for Energy Monitoring and Evaluation, Application of ICT and IoT for energy monitoring. Remote supervision of Energy use. (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
2. Energy policy for: B.V. Desai (Weiley Eastern),
3. Modeling approach to long term demand and energy implication: J.K.Parikh.
4. Energy Policy and Planning: B.Bukhootsow</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	3	2	2	1	2	1	3	2
CO2	2	2	1	1	2	1	2	3	1	1	2	2
CO3	2	2	1	1	3	1	2	2	1	2	1	2
CO4	1	3	1	3	2	1	3	1	1	2	2	1
CO5	2	3	1	1	2	2	3	2	2	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO443	NETWORK THEORY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC02(MATHEMATICS -II), EEC01 (ELECTRICAL TECHNOLOGY)		CT+MT+EA					
Course Outcomes	• CO1: Apply the knowledge of basic circuital law, like nodal analysis and mesh analysis, to write the equations for large linear and coupled circuits. • CO2: Apply Thevenin's and Norton's theorems to 12nalyse and design for maximum power transfer. • CO3: Apply the Laplace transform to linear circuits and systems and 12nalyse the signal synthesis. • CO4: Evaluate the performance of RL, RC, and RLC circuits by the application of Laplace transform. • CO5: Analyze the given network using graph theory technique. • CO6: Analyze the given network using different two port network parameters. • CO7: Determine the response of a network using the network function and draw pole-zero plots, Bode plot etc. • CO8: They will also be able to synthesize the network functions. • CO9: Students should be able to design the passive filters.							
Topics Covered	Introduction to circuit variables and circuit elements, Review of Kirchhoff s Laws, Independent and dependent Sources, Source Transformations. Solution methods applied to dc and phasor circuits: Mesh and node analysis of network containing independent and dependent sources Network topology, Network graphs, Trees, Incidence matrix, Tie-set matrix and Cut-set matrix. (8) Network theorems applied to dc and phasor circuits: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Millman's theorem, Maximum power transfer theorem. (6) Laplace transform, properties Laplace Transforms and inverse Laplace transform of common functions, Important theorems: Time shifting theorem, Frequency shifting theorem, Time differentiation theorem, Time integration theorem, s domain differentiation theorem, s domain integration theorem, Initial value theorem, Final value theorem Partial Fraction expansions for inverse Laplace transforms, Solution of differential equations using Laplace transforms							

	Transformation of basic signals and circuit into s- domain Transient analysis of RL, RC, and RLC networks with impulse, step, pulse, exponential and sinusoidal inputs. (8) Two-Port parameters: Open circuit, short circuit, transmission and hybrid parameters, relationship between parameter sets, reciprocity and symmetry conditions, parallel connections, parallel connection of two port networks. Network equivalents - Analysis of T, n, ladder, and lattice networks. (8) Network functions for the single port and two ports, properties of driving point and transfer functions, Poles and Zeros of network functions, Significance of Poles and Zeros. Time domain response from pole zero plot, Impulse Response Network functions in the sinusoidal steady state, Magnitude and Phase response. (5) Resonance: Series resonance, bandwidth, Q factor and Selectivity, Parallel resonance. Coupled circuits: single tuned and double tuned circuits, dot convention, coefficient of coupling, Analysis of coupled circuits. (7)
Text Books, and/or reference material	Text Books: 1. Kuo Franklin F., Network analysis and synthesis, 1st ed., Wiley International, 1962. 2. Van Valkenburg M.E., Network analysis, 3rd ed., Eastern Economy Edition, 1983. Reference Books: 1. Roy Chaudhary D., Network and systems, Wiley Eastern Limited. 2. Chattopadhyay D &Rakshit P C-Fundamental of Electric Circuit Theory-S chand& company Ltd. Edminister Joseph A., NahviMohmood, Electric Circuits, 3rd ed., Tata McGraw Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	1	2	1	3	3	3	2
CO2	3	3	2	3	3	1	2	1	3	3	3	2
CO3	3	3	2	3	3	1	2	1	3	3	2	3
CO4	3	3	2	3	3	1	2	1	3	3	2	3
CO5	3	3	1	1	1	1	1	1	2	3	1	2
CO6	3	3	1	3	3	1	1	1	3	3	1	2
CO7	3	3	3	3	3	1	3	1	3	3	3	2
CO8	3	3	3	1	1	1	3	1	3	3	3	2
CO9	3	3	3	1	1	1	3	1	3	3	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO441	Brain to Mind Creation	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01: Life Science		CT+MT+EA					
Course Outcomes	• CO1: Understanding Cognitive Science and the Processes • CO2: Understanding the Physics and Electrochemical Reactions in Brain.						

	• CO3 : Understanding the Behavioral Pattern of a Human Being
Topics Covered	Brain to Mind-- and how do we know it---(essentially single neuron to multiple). (4) Brain and gross specialization --- areas , right-left , association ,connectivity and our tools to learn including EEG (6) Being Conscious -- Dynamics --- how do we learn about it from EEG (8) Cognition, Memory, Emotion -- Normal and Pathology. (6) Sleep and neural network (4) Brain and Future-- with interactive session (2)
Text Books, and/or reference material	Suggested Text Books: 1) Biological basis of Behavior- Prof. Braj Bhushan 2) A Beautiful Mind - Dr. Alok Bajpai 3) Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience, 2nd Edition by Bernard J. Baars (Author), Suggested Reference Books: Principles of Neural Science, Fifth Edition by Eric R. Kandel and James H. Schwartz

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

BASKET – 2

Department of Humanities and Social Sciences								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
HSO 540	Entrepreneurship Development: Theory and Practice	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA
Course Outcomes	The students develop and can systematically apply an entrepreneurial way of thinking that will allow them to identify and create business opportunities that may be commercialized successfully.
Topics Covered	• Unit 1: Entrepreneur: Definition (3L) • Unit 2: Entrepreneur: Theory (3L) • Unit 3: Entrepreneurship: Success Story (3L) • Unit 4: Factors Affecting Entrepreneurial Growth (3L) • Unit 5: Entrepreneurial Motivation (3L) • Unit 6: Creativity (3L) • Unit 7: Financing of Enterprises (3L) • Unit 8: Forms of Business Ownership (3L) • Unit 9: Business Plan I (3L) • Unit 10: Business Plan II (3L) • Unit 11: Project Appraisal I (3L) • Unit 12: Project Appraisal II (3L) • Unit 13: Entrepreneurship Practice I (3L) • Unit 14: Entrepreneurship Practice II (3L)
Text Books, and/or reference material	**TEXT BOOKS:** 1. Donald F. Kuratko. *Entrepreneurship: Theory, Process, and Practice* ,Cengage Learning, 2008 2. Robert Baron&Scott Shane. *Entrepreneurship: A Process Perspective,*Cengage Learning, 2007 **REFERENCE BOOKS:** 1.S. S. Khanka. *Entrepreneurial Development,* S. Chand Limited, 2006. 2.GeorgeVozikis, Timothy Mescon, Howard Feldman & Eric W Liguori. *Entrepreneurship: Venture Initiation, Management and Development,*Routledge, 2013.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	3	3	2	3	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HS0541	Statistical Techniques for Economics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Develop an understanding about the basic concepts of Statistics. CO2: To be able to apply various statistical tools in analysing fundamental economic problems.						
Topics Covered	• Unit 1: Nature of Statistical Data and its Presentation (2) • Unit 2: Measures of Central Tendency (3) • Unit 3: Measures of Dispersion (3) • Unit 4: Moments, Skewness and Kurtosis (3) • Unit 5: Bivariate Data Analysis: Correlation & Regression (3) • Unit 6: Time Series (4) • Unit 7: Set Theory (3) • Unit 8: Theory of Probability, Random Variables and Expectation (5) • Unit 9: Univariate Probability Distributions (4) • Unit 10: Sampling Theory and Distributions (4) • Unit 11: Theory of Estimation (4) • Unit 12: Theory of Testing of Hypothesis (4)						
Text Books, and/or reference material	**Text Books** • Goon, Gupta and Dasgupta – Fundamental of Statistics, Vol. I & II, World Press Private Ltd, 2013, 2016. • Gupta and Kapoor – Fundamental of Mathematical Statistics.S.Chand & Sons, 2014. **Reference Books** • A. M. Mathai&P. N. Rathie – Probability and Statistics. Palgrave MacMillan. 2014. • William G. Cochran - Sampling Techniques. Wiley& Sons. 2007. • Sheldon Ross- A First Course in Probability. Pearson Education India. 2013. • D. R. Agarwal – Comprehensive Statistics. Vrinda Publications (p) Ltd. 2011.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	1	-	-	-	2	-
CO2	1	-	-	3	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO543	Personality Development	PEL	42	0	0	42	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
None	CT+MT+EA
Course Outcomes	• CO1: To develop the all-round personality of students • CO2: To make students confident enough to face any situation with optimistic zeal.
Topics Covered	Personality: Meaning and Possibilities. (2) Characteristics of a healthy personality. (4) Grooming and blooming personality: Critical approaches. (6) Self and the other: balancing the binaries (8) Communication Skills: verbal and non-verbal. (10) Behavioural health and wellness. (8) Decision and implementation: measures and challenges. (4)
Text Books, and/or reference material	Suggested Text Books: 1. Carnegie, Dale. *How to Win Friends and Influence People*. Amazing Reads, 2016. 2. Peale, Norman Vincent. *The Power of Positive Thinking*. RHUK, 2016. Suggested Reference Books: 1. Csikszentmihalyi, Mihaly. *Flow: The Psychology of Optimal Experience*. Harper Perennial Modern Classics, 2018. 2. Canfield, Jack et al. *Chicken Soup for the Unsinkable Soul*. Backlist LLC, 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	-	2	-	2	-	3	3	2	3	3	-	2
CO2	-	3	-	2	-	3	2	2	3	3	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO544	Soft Skills	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	• CO1: Learners will have a good grasp of soft skills in its different variants • CO2: Learners will be better equipped to showcase and share their knowledge and skills • CO3: Learners will be better prepared for employment opportunities and career growth
Topics Covered	1. Concept of Soft Skills (4) 2. Personality Traits (4) 3. Confidence Building (4) 4. Workplace Communication (4) 5. Employability (4) 6. Facing Interview (4) 7. Team Spirit (4) 8. Motivational Leadership (5) 9. Workplace Etiquette (4) 10. Intercultural Soft Skills (5)
Text Books, and/or reference material	Suggested Text Books: 1. *Soft Skills & Employability Skills*. Sabina Pillai & Agna Fernandez. Cambridge University Press. 2. *Soft Skills*. K. Alex. S. Chand Suggested Reference Books: 1. *You Can Win*. Shiv Khera. Penguin.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	3	-	3	-	3	-	3
CO2	1	2	2	2	2	-	3	-	3	-	1	3
CO3	-	-	-	-	-	3	3	3	3	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAO541</td><td>Mathematical methods for engineers</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), Mid-term assessment (MA) and end assessment (EA))</td></tr>
<tr><td colspan="2">MAC02 (Mathematics-II)</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">• CO1: Students will be able to understand and solve the difference equations that are used to model various engineering problems.
• CO2: To enable the students to apply integral transforms to problems formulated on finite or infinite domains and also to solve engineering and physical problems involving PDEs in a simpler way using integral transforms.
• CO3: To enable the students to solve a discrete systems using Z-Transform.</td></tr>
</table>

	• CO4: Students will have an in-depth knowledge of power series solution of differential equations and also will learn about special functions which arise in many engineering and physical problems.
Topics Covered	**Difference Equations:** Formation of difference equation, First and higher order difference equations, Reduction of non-linear difference equation into linear form, Solution of difference equations. (6) **Z-transform:** Some standard Z- transforms, Properties of Z-transform, Damping rule, Shifting rule, Initial and final value theorem, Convolution theorem, Inverse Z-transform, Solution of difference equations using Z-transform. (6) **Series Solution of Ordinary Differential Equations:** Validity of series solution, Series solution about an ordinary point and about a regular singular point, Bessel's equation and Bessel functions, Recurrence relations of Bessel functions, Generating function for $J_n(x)$, Orthogonality of Bessel functions, Legendre's equation and Legendre functions, Legendre polynomial, Rodrigue's formula, Generating function for $P_n(x)$, Recurrence relations for $P_n(x)$, Orthogonality of Legendre polynomial. (15) **Application of Fourier Transforms:** recapitulation of Fourier transform & its properties, solution of partial differential equations using Fourier transform (6) **Application of Fourier Transforms in mathematical statistics (2)** **Finite Fourier Transforms:** Finite Fourier Sine & Cosine transform, basic properties, applications of finite Fourier Sine & Cosine transform in the solution of boundary value problems (7)
Text Books, and/or reference material	**Text Books:** 1. S. L. Ross: Differential Equations: John Willey and Sons. 2. I. N. Sneddon: The use of Integral Transforms, McGraw-Hill, 1974. 3. E. Kreyszig: Advanced Engineering Mathematics: 10thedition, Wiley India Edition (2010). **Reference Books:** 1. M.D. Raisinghania: Advanced differential equations: S. Chand Publication. 2. L. Debnath & D. Bhatta: Integral Transforms and their applications: 2nd Edition, Chapman & Hall/CRC.

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO12
MAO541	CO1	3	3	3	2	1	1	1	-	1	1	-	2
	CO2	3	3	2	2	1	1	1	-	1	1	-	2
	CO3	3	2	2	2	2	1	1	-	1	1	-	3
	CO4	3	2	2	2	2	1	1	-	1	1	1	3

Department of mathematics						
Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
		Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
Linear Algebra	PEL	3	0	0	3	3
Pre-requisites	MAC02					
Course Assessment methods (Continuous (CT) and end assessment (EA))	CT+EA					
Course Outcomes	• CO1: Solve systems of linear equations using several methods, including Gaussian elimination and matrix inversion					

	• CO2: Demonstrate understanding of the concepts of vector space and subspace, linear independence, span, and basis and use these for analysis of matrices and systems of linear equations. • CO3: Determine eigenvalues and eigenvectors and solve eigenvalue problems; apply principles of matrix algebra to linear transformations; discriminate between diagonalizable and non-diagonalizable matrices; demonstrate understanding of inner products and associated norms.
Topics Covered	• Systems of linear equations, Matrices, Elementary row and column operations, Row-reduced echelon matrices. Gaussian elimination, LU-Decomposition. (6) • Vector spaces, Subspaces, Linear span, Linear dependence and independence, Basis and dimension, ordered basis and coordinates, Row space and column space, Direct-sum decompositions. (12) • Linear transformations, Rank-Nullity theorem, Matrix representation of linear transformations. (7) • Eigenvalues and eigenvectors, Cayley-Hamilton theorem, Diagonalization of Matrices, Minimal polynomial, rational canonical form, Jordan canonical form. (13) • Inner Product Spaces, Orthonormal Basis, Gram-Schmidt Theorem. (4)
Text Books, and/or reference material	**Text Books:** 1. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall of India, New Delhi, 1990. 2. S. K. Mapa, Higher Algebra, Sarat Book Distribution, 2000. **Reference Books:** 1. S. Lang, Linear Algebra, Springer, Third Edition. 2. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning Pvt. Ltd., 2000.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
MAO542	CO1	3	2	1	-	1	-	1	1	-	-	-	2
	CO2	3	3	1	1	1	-	1	-	-	-	-	2
	CO3	3	3	2	1	1	1	1	-	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO543	Modern Algebra	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire an idea about abstract mathematical problems • CO2: To understand the principle of symmetric objects • CO3: To learn the basic tools of vector spaces, coding theory and						

	cryptography
Topics Covered	Preliminary concept: Sets and Equivalence relations and partitions, Division algorithm for integers, primes, unique factorizations, Chinese Remainder Theorem, Euler ɸ-function. [10] Groups: Cyclic groups, Permutation groups, Isomorphism of groups, Cosets and Lagrange's Theorem, Normal subgroups, Quotient groups, Group homomorphisms, Cayley's theorem, Cauchy's theorem. [12] Rings: Ideals and Homomorphism, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Polynomial Rings. [10] Fields: Vector space, Field extensions, Finite Fields. [10]
Text Books, and/or reference material	**Text Books:** 1. *J. B. Fraleigh, A First Course in Abstract Algebra*, Addison Wesley, 2013. 2. *I. N. Herstein, Topics in Abstract Algebra,* Wiley Eastern Limited, 1975. **Reference Books:** 1. *T. W. Hungerford, Algebra, Springer*, 2009. **2.** *D. S. Dummit, R. M. Foote, Abstract Algebra*, Second Edition, John Wiley & Sons, Inc., 1999. **3.** *G. A. Gallian, Contemporary Abstract Algebra*, Narosa Publishers, 2017.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
MAO5 43	CO1	3	3	2	2	1	-	1	1	-	-	1	1
	CO2	3	3	1	1	1	1	1	-	-	-	-	-
	CO3	3	2	1	3	2	-	-	-	1	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO541	**Thin Film Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To understand growth mechanism of thin film CO2: To comprehend application of thin film in modern devices CO3: To be familiar with characterization technique of thin film CO4: To know about the industrial applications of thin film						
Topics Covered	**Introduction:** Basic of Thin films and Nanostructures, Role of thin films in Devices. [2] **Nucleation, film growth and structure**: Thermodynamics of Nucleation, Nucleation theory: Capillarity Model and Statistical Model, Comparison of two models, Film growth: Volmer-Waber growth, Frank-Vander-Merwe and Stranski-Krastonav growth, Dissociations, Doping and diffusion effects, Film thickness. [9] **Deposition Technique**: Thermal Evaporation: Resistive heating, Flash evaporation, Arc evaporation, Laser evaporation, rf heating, Electron bombardment heating, Sputtering: Glow discharge sputtering, Low pressure sputtering, Reactive sputtering, rf sputtering,						

	Chemical Methods: Electro-deposition, Electrolytic deposition, Chemical Vapour deposition, Liquid phase epitaxy, Molecular beam epitaxy, Spin coating, Sol gel, Langmuir Blodgett (LB) Techniques. [12] **Thin Film Characterization:** X-ray diffraction and G-XRD method, Atomic force microscope (AFM) method for determination of surface roughness, Scanning tunneling microscopy (STM), Thickness measurement techniques (ellipsometer), Field emission scanning electron microscopy (FESEM), Transmission electron microscopy (TEM), Hall effect, UV-vis spectroscopy, photo luminance process, Schottky contact, Ohmic contact, Photocurrent and photocapacitance measurement. [12] **Thin film Devices:** Applications of different thin films in modern technology, Photo diode, LED and Solar cell. [7]
Text Books, and/or reference material	**TEXT BOOKS:** 1. Thin Film Phenomena, K. L. Chopra 2. An Introduction to Physics and Technology of Thin Films, Part – I & II, A. Wagendristel & Y. Wang. 3. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan **REFERENCE BOOKS:** 1. Thin Film Fundamentals, A. Goswami 2. Handbook of Thin Film Technology, Maissel and Glange 3. Thin Film Solar Cells, S. R. Das and S. P. Singh

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
PHO 541	CO1	3	1	2	3	1			1				1
	CO2	3	3	2	2			2	1				1
	CO3	3	2	2	2	1	1	1	1	1	1	1	1
	CO4	3	2	2	2	1	1	1	2	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO540	Mineral Biotechnology	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA
Course Outcomes	• CO1: To understand the nature and characteristics of different biogeochemical cycles and involvement important micro-organisms. • CO2: To learn the basic concepts of bioleaching and bio-beneficiation along with the microbiological aspects • CO3: To gain the detail knowledge bioleaching processes with

	examples. • CO4: To demonstrate and provide examples on how to use microbes for the environmental pollution control
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8
Text Books, and/or reference material	Suggested Text Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology , Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235 , 1983 Suggested Reference Books: 1. Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	2	1	1	-	1	-	-	1
CO2	2	1	1	-	1	-	2	1	1	1	-	1
CO3	2	1	1	1	1	-	1	-	1	-	-	1
CO4	2	1	1	1	1	-	2	1	1	1	1	1

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR)/ Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO54 1</td><td>Introduction to Computational Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Life Science BTC01</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">· CO1: To impart knowledge of life science and biological data
· CO2: To acquire knowledge of computational and mathematical skills for addressing important biological questions.
• CO3: To learn how to develop and implement computational algorithms and tools for processing biological data</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction to Computational biology and its applications(2)
2. Central dogma and biological macromolecules- DNA, RNA & proteins(2)
3. Major biological databases related to DNA, RNA, proteins & metabolic pathways(3)
4. Basic file formats & sequence representation(2)
5. Computational algorithms for Sequence Alignment: Local and global alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7)
6. Algorithms for phylogenetics: Tree constructions(5)
7. Structural Bioinformatics:
· Protein Structure and its visualization(2)
· Protein structural alignment(3)
· Protein secondary Structure Prediction(4)
· Protein tertiary Structure Prediction(4)
· RNA Structure Prediction(3)
· Molecular docking and docking algorithms(3)
8. Application of machine learning in biological sciences (Basic concepts) (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor LaboratoryPress
2. Introduction to Bioinformatics by Arthur MLesk
<u>Suggested Reference Books:</u>
1. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R.Taylor.
2. Essentials of Bioinformatics by JinXiong</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1			1	1			1			
CO2	3	3	2		2	1			2			
CO3	3	3	2	2	3	1		1	3	1	2	1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO540	**Numerical methods in Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Engineering Mathematics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	· CO1: Assess the error involved in a numerical method · CO2: Solve problems in engineering and science with a required accuracy using appropriate numerical methods · CO3: Write algorithm for the numerical methods for efficient coding of program · CO4:Understand the mathematics concepts underlying the numerical methods
Topics Covered (Hrs)	**Fundamentals of numerical methods:** Need for Numerical methods in Civil Engineering, Sources of Errors, Absolute, Relative and Percentage, round off error, and stability of algorithms. **(4)** **Linear system of algebraic equations:** Gauss elimination method, LU decomposition method; iterative methods, ill conditioned systems. Jacobi, Gauss Seidel method, Relaxation method. **(8)** **Nonlinear equations:** Bisection method, Regula Falsi method, Newton Raphson method, Modified Newton-Raphson method, Higher order Newton's method Bairstow method, system of non-linear equations. **(8)** **Interpolation and approximation**: Newton's, Lagrange and Hermite interpolating polynomials, cubic splines; least square and minimax approximations**. (6)** **Numerical differentiation and integration:** Newton-Cotes and Gaussian type quadrature methods. **(6)** **Ordinary differential equations:** Initial value problems: single step and multistep methods, stability and their convergence. Boundary value problems: functional approximation, finite difference method. **(8)**

Text Books, and/or reference material(s)	***Text Books:*** 1. Numerical Methods for Scientists and Engineers by R. W. Hamming, Dover Publications; 2 edition 2. Numerical Methods: Problems and Solutions by Mahinder Kumar Jain (Author), S.R.K. Iyengar (Author), R. K. Jain, New age publishers 3. Numerical Methods for Engineers by Chapra, S. C., and Canale, R. P., McGraw Hill, Inc., 2007. ***Reference Books:*** 4. Applied Numerical Methods for Engineers Using Matlab and C by Robert J. Schilling (Author), Sandra L. Harris, Nelson Engineering; Har/Cdr edition 5. Numerical Analysis for Scientists and Engineers: Theory and C Programs by Madhumangal Pal, Alpha Science Intl Ltd; 1 edition

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO9	PO10	PO11	PO 12
CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	3	-	3	-	-	-	-	-	-	-
CO3	3	-	3	-	3	-	-	-	-	1	-	-
CO4	2	-	-	-	3	-	1	-	-	-	-	-

Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				**Credit**
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO541	**Engineering Computing & Simulation with Scilab**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering Mathematics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	· CO1: Understand the basic elements of scilab language. · CO2: Compute different mathematic operations like scalars, vectors, matrix, statistics and probability, ordinary differential equations by using scilab. · CO3: Use modern software tools scilab. · CO4: Use scilab to simulate the different engineering problems.						
Topics Covered (Hrs)	**Introduction:** Introduction to scilab, scilab environment, workspace, working directory. **(2)** **Basic elements of the language:** Basic elements of the scilab language. **(2)** **Basic mathematical operations or functions:** Scalars & vectors, matrix operations, ordinary differential equations, statistics, probability functions using scilab. **(10)** **Plotting with scilab:** Plotting 2D and 3D graphs using scilab**. (4)** **Simulation techniques:** Monte Carlo method, Latin Hypercube simulation,						

	Variation reduction techniques. **(10)** **Scilab functions:** script files and functions files, different functions in scilab. **(6)** **Applications:** Programming with scilab and solve different engineering problems. **(6)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Engineering and Scientific Computing with Scilab by C. Bunks, J. P Chancelier, F. Delebecque, C. Gomez, M. Goursat, R. Nikoukhah, and S. Steer., Birkhäuser; 1999. 2. Modelling and Simulation in Scilab/Scicos by Stephen L. Campbell, Jean-Philippe Chancelier, and Ramine Nikoukhah, Springer. 2010. 3. A Practical Introduction to Programming and Problem Solving by Tejas Sheth, Scilab, Create Space Independent Publishing Platform, 2016. ***Reference Books:*** 4. Scilab by Example by M. Allouf, Create Space Independent Publishing Platform, 2012.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	1	2	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	-	1	2	2	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO542	**Introduction to Random Vibrations**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)			Course Assessment methods				
Basic Engineering vibrations, statistics and probability			Continuous (CT) and end assessment (EA). CT+EA				
Course Outcomes (COs) :	· CO1: Development of skills for predicting engineering system behaviour under random vibrations · CO2: Knowledge of basics of random vibration analysis for further applications. · CO3: Developing the requisite skill that helps in the advanced courses related to random vibration study.						

Topics Covered (Hrs)	**Review** of basic topics in probability theory and vibrations **(4)** **Introduction** to the theory of random processes Time- and frequency-domain characteristics Stationary and nonstationary processes Continuity, differentiation and integration, Poisson, Gaussian processes. **(10)** **Random vibration** of linear structures Unit-impulse and frequency-response functions Time- and frequency-domain analysis Single- and multi-degree-of-freedom systems Stationary and nonstationary responses State-space formulation Modal cross-correlations Response to multi-support excitation, coherency function **(12)** **Crossings and reliability** analysis Threshold Crossings The envelope process First passage probability Distribution of local and extreme peaks **(8)** **Response spectrum** methods Response spectrum methods (CQC, CQC3, MSRS) PSD consistent with response spectrum. **(8)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Probabilistic Theory of Structural Dynamics by Y. K. Lin, McGraw-Hill, New York, NY, 1967 Krieger Pub., Huntington, NY, 1976. **2.** Probabilistic Structural Dynamics: Advanced Theory and Applications by Y. K. Lin and G.Q. Cai, McGraw-Hill, New York, NY, 1995. ***Reference Books:*** 3. An Introduction to Random Vibrations, Spectral & Wavelet Analysis: Third Edition by D.E. Newland, Dover Publications, Mineola, NY, 2005. 4. Introduction to Random Vibrations by N. C. Nigam, MIT Press, Cambridge, MA, 1983. 5. Applications of Random Vibrations by N.C. Nigam and S. Narayanan, Narosa Pub., New Delhi,India, 1994.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	-	-	-	2	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit (C)
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours (H)	
CHO 541	**SOLID & HAZARDOUS WASTE MANAGEMENT WITH A HOLISTIC APPROACH**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Environmental Science		CT+MT+EA					
Course Outcomes	• CO1: Become aware of environment and health impacts of solid & hazardous waste & knowledge of legal aspects of management of solid & hazardous wastes.						

<table>
<tr><td></td><td>

CO2: Identify improper practices of solid & hazardous waste disposal and their environmental implications. Know the basic engineering principles of solid & hazardous waste management
CO3: Conceive the design aspects of engineered disposal options and apply the gained knowledge to solve numerical examples.

</td></tr>
<tr><td>Topics Covered</td><td>
Module I:
Air Pollution: Sources, Health Hazards, global warming & climate change.
Introduction to water pollution
Introduction on sustainable development goal (SDG).
Nature as a collection of Units, Classification of Units into four orders, Interconnectedness and mutual fulfilment among the four orders, Dependence of the human being on the other three orders, my participation in nature, vision for holistic technologies, production system and management models.
Relevant Regulations of waste management
Municipal solid waste (management and handling) rules;
hazardous waste (management and handling) rules;
biomedical waste handling rules;
flyash rules; recycled plastics usage rules; batteries (management and handling) rules. [14 hrs.]
Module II:
Municipal Solid Waste Management – Fundamentals
Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options
Hazardous Waste Management – Fundamentals
Characterization of waste; compatibility and flammability of chemicals; fate and transport of chemicals; health effects
Physicochemical Treatment of Solid and Hazardous Waste
Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes);
physicochemical processes for hazardous wastes (soil vapor extraction, air stripping, chemical oxidation); ground water contamination and remediation. [14 hrs.]
Module III:
Biological Treatment of Solid and Hazardous Waste
Composting; bioreactors; anaerobic decomposition of solid waste;
Principles of biodegradation of toxic waste; inhibition; co-metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation.
Landfill design for solid and hazardous wastes; leachate collection and removal; landfill covers;
Thermal Treatment (Incineration)
Introduction on greywater management, Faecal sludge management, Bio-degradable waste management. [14 hrs.]
</td></tr>
<tr><td>Text Books, and/or reference material</td><td>
<u>Suggested Text Books:</u>
1. Integrated solid waste management, G. Tchobanoglous, H. Theisen, S. A Vigil, Mc Graw Hill, 2019
2. John Pichtel Waste Management Practices CRC Press, Taylor and Francis Group 2005.
3. LaGrega, M.D. Buckingham, P.L. and Evans, J.C.
4. Hazardous Waste Management, McGraw Hill International Editions, New York, 1994.
<u>Suggested Reference Books:</u>
1. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors John Wiley and Sons, New York, 1997.
2. Elements of Environmental Science and Engineering, P. Meenakshi, PHI (1 December 2012)
3. Environmental Pollution Control Engineering – C.S. Rao
</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2			3	3	3			1	2
CO2	3	1	2			3	3				1	2
CO3	3	1	2			3	3				1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="10">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CHO542</td><td colspan="2">FUELS & COMBUSTION</td><td>PEL</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: Learn different sources of energy and basic terminology
• CO2: Identify characteristic properties of fuels and analyze fuel processing equipment
• CO3: Compare performances and select type of fuel processing equipment</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Module I:
Introduction: Survey of different sources of energy and their utilization.
Fossil fuels: Coal, Petroleum and gaseous fuels.
Coal: Origin and formation of coal. Petrographic constituents of coal, Properties and testing. Classification of coal, Coal preparation- washing and blending, Metallurgical and other uses. Carbonisation of coal, coke ovens and recovery of by-products. [15 hrs.]
Module II:
Petroleum: Constitution of petroleum, Origin and Occurrence of crude, Evaluation of crude, Properties, testing and specifications of petroleum products- Octane no.; Reid vapor pressure; Flash point; Fire point; Smoke point; Pour point; Cloud point; Aniline point and Diesel index; Cetane no., Processing of Crude Petroleum. [12 hrs.]
Module III:
Gaseous fuels: Classification. Manufacture of producer and water gas.
Combustion and furnace: Combustion characteristics, Combustion appliances--furnaces, waste heat recovery system, burners. [11 hrs.]
Module IV:
Non-conventional energy sources: Solar energy, Wind, Tidal Energy, Wave Energy, Energy from biomass, [4 hrs.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8"><u>Suggested Text Books:</u>
1. Modern Petroleum Refining: B. K. B. Rao
2. Fuels & Combustion: Samir Sarkar
<u>Suggested Reference Books:</u>
1. Petroleum Refining Engineering: W. L. Nelson
2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwerk
3. The elements of fuel technology: G. W. Himus</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO 543	**INDUSTRIAL WATER TREATMENT**	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Learn different sources of energy and basic terminology • CO2: Identify characteristic properties of fuels and analyze fuel processing equipment • CO3: Compare performances and select type of fuel processing equipment						
Topics Covered	**Module I:** Introduction to water resource management issues, access to safe drinking water, river pollution, water quality standards, sources and classification of pollutants.[4hrs.] **Module II:** Chemical Treatment Technology: aeration, chemical coagulation-precipitation, neutralization, chemical oxidation, adsorption, ion-exchange, And advanced oxidation, disinfection of water [6 hrs.] **Module III:** Biological Water Treatment Technology: Biodegradability of water pollutants, selection of technology, microbial growth kinetics, bioreactor configurations, conventional biological treatment, hybrid biological treatment, advances in biological treatment [8 hrs.] **Module IV:** Water treatment by membrane technology: Membrane-based processes, membrane modules, micro, ultra, nano, reverse osmosis, membrane distillation in water treatment. Forward osmosis, FO-NF integrated technology [8 hrs.] **Module V:** Industry-specific treatment of water: Coke oven wastewater treatment, Pharmaceutical wastewater treatment, tannery wastewater treatment, petroleum refinery wastewater treatment, pulp and paper industry wastewater treatment [7 hrs.] **Module VI:** Nanotechnology in water treatment, Hybrid Water Treatment Technologies: Chemical-biological, biological-membrane, membrane-c chemical hybrid treatment technologies in water treatment, sustainable water treatment, ethics, compliance of regulations [7hrs.]							
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Industrial Water Treatment Process Technology, P. Pal, Elsevier Science 2. Groundwater Arsenic Remediation: Treatment Technology and Scale Up, P.Pal, Elsevier Science <u>Suggested Reference Books:</u> 1. Wastewater Treatment, Disposal, Reuse, Eddy and Metcalf							

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	3	2	3	3	3	2	3
CO2	3	3	3	1	3	3	2	3	3	3	3	3
CO3	3	3	3	1	3	3	2	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO541	Fundamentals of Algorithms	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Will be able to analyse the time complexity of algorithms. • CO2: Able to map real life problems into algorithmic framework. • CO3: Will have concept of different algorithm design paradigm.						
Topics Covered	1. Non-linear data structures. Trees. Binary search trees, AVL tree. (5L) 2. Set Representations. Disjoint Set Union. Priority Queues. (4L) 3. Graph Representations. AND-OR graphs. BFS. DFS. (4L) 4. Algorithm analysis techniques, asymptotic complexity, Big-Oh, Big-omega and Theta notation, Lower bound analysis. (5L) 5. Divide and Conquer. Analysis of Binary Sort, Merge sort, Heap sort, Quicksort, Selection problem, Multiplication of two large n-bit numbers, Strassens' Matrix Multiplication. (7L) 6. Greedy Techniques. Minimal Spanning Trees, Knapsack problem, Huffman's Codes. Job Scheduling. (6L) 7. Dynamic Programming. All Pairs. Shortest Paths, Matrix Chain Multiplication Problem, Traveling Salesperson Problem. (5L) 8. Backtracking. N-Queens problem. Sum of Subsets. (3L) 9. Introduction to NP Hard problems. (3L)						
Text Books, and/or reference material	**Text Books:** 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, by Prentice Hall India. 2. J. Kleinberg and Eva Tardo, Algorithm Design by Pearson Education (Indian edition). **Reference Books:** 1. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Wiley, 2006.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	-	-	-	-	-	-	2
CO2	2	3	3	3	2	-	-	-	-	-	-	2
CO3	2	3	3	3	2	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2" colspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO542</td><td>Database Management System</td><td colspan="2">PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Fundamental knowledge in Programming and Data Structures</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Understand the basic concepts and appreciate the applications of database systems.
CO2: Comprehend the fundamentals of design principles for logical design of relational databases.
CO3: Apply the query writing skill and its subsequent optimization.
CO4: Discuss the basic issues of transaction processing and concurrency control.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Introduction: Concept & Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS. (3L)
Entity-Relationship Model: Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram. (5L)
Relational Model: Structure of relational Databases, Various Relational Algebra operations used to write a query, Views. (5L)
SQL: Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Referential views, Nested Subqueries. (5L)
Index Structures: Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes. (3L)
Normalization: Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Fourth Normal form and fifth normal form, Denormalization, Loss-less join decomposition, Dependency preservation. (6L)
Transaction processing: Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability. (4L)
Concurrency Control: Serializability by Locks, Lock Modes, Lock based Concurrency Control, Concurrency Control by Timestamps. (4L)
Query Optimization: Heuristics in Query Optimization, Converting Query Tree to Query Evaluation Plan. (3L)
Distributed Database (DDB): Introduction of DDB, DDBMS architectures, Data Replication, Data Fragmentation. (4L)</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. "DatabaseSystem Concepts", Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill. 2. "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. **Reference Books:** 1. "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	1	1	1	1	1	2	2
CO2	3	3	3	3	2	2	2	1	1	2	2	2
CO3	2	3	3	3	3	2	1	1	2	2	2	2
CO4	3	2	2	2	1	1	1	1	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO543	Computer Organization	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
CSC01 (Introduction to Computing)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Analyze the various parts of a modern computer functional units, bus structure, addressing modes and Computer arithmetic. • CO2: Identify the process involved in executing an instruction and fetching the word from memory. • CO3: Design the hardwired and micro-programmed control units and implementation of interrupts. • CO4: Understand the memory hierarchy and design a memory system.						
Topics Covered	**UNIT-I**: Introduction: Evolution of computers, Basic Structure of Computers: Basic Operational Concepts, GPR based and stack based organisation. Bus Structures, Performance Measurement: Processor Clock, Basic Performance Equation, Clock Rate, Machine Instructions and Programs: Memory Location and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes. (10L) **UNIT-II**: Fundamental concepts of the processing Unit: Fetching and Storing words, Register Transfer, Execution of instruction, Arithmetic Operations: Addition and Subtraction of Signed Numbers, Design of Fast Adders, Combinational and Sequential ALU, ALU expansion strategies, Floating Point Numbers (IEEE754), Floating Point Operations. (10L) **UNIT-III**: Computer Organization and Design (Datapath and control path): Instruction codes, computer registers, computer instructions, timing & control, instruction cycle, memory reference instructions, Hard-wired Control, Micro programmed Control: Micro instruction, Microprogram sequencing, Input/output Organization: Accessing I/O Devices, Interrupt, Bus Arbitration schemes. (Brief overview of 8085/8086 microprocessor). (12L) **UNIT-IV**: Memory System: Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, Cache Memories – Mapping						

	Functions, Replacement Algorithms, page mode access, interleaved access. Performance Considerations, Virtual Memories, Secondary Storage. (10L)
Text Books, and/or reference material	**Text Books:** 1. David A Patterson, John L Hennessy, "Computer Organization and Design", (The Hardware/Software Interface) Morgan Kaufmann. 2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky: Computer Organization, 5th Edition, Tata McGraw Hill. **Reference Books:** **1. William Stallings, "Computer Organization and Architecture".** 2. Nicholas P Carter, "Computer Architecture & Organisation".

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	1	-	-	-	-	-	-	1
CO2	3	1	2	2	1	-	-	-	-	-	-	-
CO3	3	1	3	3	1	-	-	-	2	-	-	-
CO4	3	2	3	3	2	-	-	-	1	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO544	Operating Systems	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Introduction to Computing (CSC01), Data Structures and Algorithms (CSC303)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Explain the functional architecture of an operating system. • CO2: Design the process control algorithms, solution to deadlocks and multi-threading applications • CO3: Implement application programs using UNIX system calls. • CO4: Design and solve control & data access synchronization problems. • CO5: Explain virtual memory organization and management in OS. • CO6: Implementation of standard FAT & UNIX file system.						
Topics Covered	**Introductory Concepts:** Introduction to Operating System as a whole, memory, CPU (registers and ALU), Evolution of Operating System-types of OS(advantages and drawbacks), Performance measurement metrics. (4L) **Process Data Structures and State transitions:** Process management, Basic Definitions, Process table, PCB (process control block), PTE(process table entry), Process states, Transition diagram, context of process-user level, kernel-level and process Level. (3L) **Process Control:** Process creation, Parent and Child processes, System calls--fork(), exit(), wait(), kill(), Signal handling, Process scheduling strategies-FCFS, SPN, SRT, Round Robin, HRRN, Fair share scheduling. (5L) **Multi-threading:** Threads in OS, thread vs process, Applications of threads, Use of POSIX threads library. (3L) **Process synchronization -** Race condition, Critical section, Process Sync Solution using Algorithmic approach (Lamport bakery Algorithm), Creating shared memory using POSIX library. (2L) **Semaphore-** Binary and Counting semaphore, P() and V() operations, Solving Classical problem using semaphores- Sleeping barber, Producer-						

	consumer, Reader-writer, Dining philosophers's problem, Posix library for semaphores. (6L) **Deadlocks** - Necessary and sufficient conditions for deadlocks, approaches to deal with deadlocks, Deadlock Prevention, Avoidance (Banker's algorithm) and Detection. (3L) **Memory organization & management** - Virtual memory organization, Pure Paging, Pure Segmentation, Combined Paging-Segmentation, Inverted PMT, Page fault handling algorithms, Working set theory. (10L) **File management**- Directory structure, Storage of files on disks, contiguous and non-contiguous file allocation strategies, Internal and external fragmentation, FAT & Inode Structure, Free Space management, Disk scheduling strategies. (4L) **I/O management concepts** (2L)
Text Books, and/or reference material	**Text Books:** 1. "Operating System Concepts", Silberschatz and Galvin. 2. "Operating Systems: Internals and Design Principles" by William Stalling. 3. "Operating Systems: A Concept-Based Approach" by D M Dhamdhere. **Reference Books:** 1. "Operating System: A Design-oriented Approach" by Charles Crowley. 2. "Operating Systems: A Modern Perspective" by Gary J Nutt. 3. "Design of the Unix Operating Systems" by Maurice Bach. 4. "MODERN OPERATING SYSTEMS" by Andrew S Tanenbaum. **Others:** • https://nptel.ac.in/courses/106/106/106106144/# Course "Introduction to Operating Systems" by PROF. CHESTER REBERIO, IIT Madras. • https://nptel.ac.in/courses/106105214/ Course "Operating System Fundamentals" by Prof. Santunu Chattopadhyay, IIT Kharagpur.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	2	1	-	1	2	1
CO2	3	3	1	3	3	1	-	-	-	1	-	-
CO3	-	3	3	-	3	-	-	-	-	1	1	1
CO4	1	3	2	3	3	1	-	-	-	1	3	1
CO5	1	2	2	3	3	1	-	-	-	1	3	1
CO6	-	-	3	-	3	3	2	-	1	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO540	Mechatronics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	• CO1: **Understand** characteristics of mechatronics system • CO2: **Apply qualitative analysis** techniques in mechatronics system • CO3: **Apply quantitative analysis** techniques in mechatronics system • CO4: **Understand** basic building blocks of general mechatronics system • CO5: **Design** general mechatronics system with functional blocks • CO6: **Investigate complex designs** in mechatronics system and case studies
Topics Covered	Introduction to mechatronics (1L) Sensors and Transducers, Pneumatic and Hydraulic, Mechanical Actuation Systems, Electrical actuation systems (8L) Signal Conditioning circuits (4L) Digital Processing Elements (3L) Data Presentation Systems (2L) System models and Dynamic response (3L) System Transfer functions and frequency response (3L) Closed loop controllers (2L) Artificial Intelligence (2L) Microcontrollers and programming (4L) Interfacing and communication (2L) Case studies (8L)
Text and/or reference Books	**Text Book**: 1. Mechatronics, by W. Bolton, Fourth Edition, Pearson

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	1	1	1	1	1	1	1	1	1	1
CO#2	3	2	1	1	1	1	1	1	1	1	1	1
CO#3	2	3	1	1	1	1	1	1	1	1	1	1
CO#4	1	1	3	2	1	1	1	1	1	1	1	1
CO#5	1	1	3	2	1	1	1	1	1	1	1	1
CO#6	1	1	2	3	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO541	Probability Theory for Engineering Application	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	CO1: Characterize probability models and random variables. CO2: Evaluate moments, correlation, and understand the concept of point estimation, hypothesis testing, inequalities and probabilistic limits. CO3: Recognize, interpret and apply a variety of statistical methods that occur

	in engineering.
Topics Covered	1. Introduction: Basics of probability theory and statistics for engineers, total probability theorem, Bayes' theorem, Bernoulli's Trials. (3L) 2. Continuous type random variables: CDF, PDF; Types – uniform, exponential, Gaussian, Rayleigh, Weibull etc. Markov inequality, Chebyshev's inequality, Function of random variables, moments and characteristics function. (7L) 3. Discrete type random variables: conditional PMF, Types – Binomial, Geormetric, etc.; mean, variance of discrete random variables. (3L) 4. Two random variables: Joint density and distribution function, independence, two functions of two random variables, and central limit theorem. (3L) 5. Frequency distribution, histogram, random sampling, sampling distributions, t- distribution, chi-square distribution, CLT, point estimation, ML estimation, MAP, method of moments, interval estimation, confidence intervals. (8L) 6. Hypothesis testing, type I and type II errors, p values; t – test, goodness of fit. (5L) 7. Nonparametric test: the sign test, Wilcoxon rank sum test, F distribution, F – test, Chi-square test. (5L) 8. Regression analysis, correlation, analysis of variance (ANOVA), MTBF, reliability. (8L)
Text Books, and/or reference material	**Text Books**: 1. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, 5th Ed., New Delhi, 2014. 2. Bruce Hajek, *Probability with Engineering Applications, ECE 313 course notes*; Dept. of Electrical and Computer Engineering, University of Illinois, January 2013. 3. J. Ravichandran, *Probability and Statistics for Engineers*, 1st Ed., Wiley, New Delhi, 2014. 4. George R. Cooper, C. D. McGillem, *Probabilistic Methods of Signal and System Analysis*, Oxford University Press, 3rd Ed. , New Delhi, 2007 **Reference Books**: 5. K. S. Trivedi, *Probability and Statistics with Reliability Queuing and Computer Science Applications*, 2nd Ed., Wiley, New Delhi, 2016. 6. Alberto Leon-Garcia, *Probability and Random Processes for Electrical Engineering*, Pearson Education Inc., 2nd Ed., 2007 7. B. S. Grewal, *Higher Engineering Mathematics*, 4th Ed., Khanna Publishers, Delhi, 1998. 8. Erwin Kreyszig, *Advanced Engineering Mathematics*, 9th Ed., Wiley, Delhi, 2013. **Other references**: 9. R. Maity, *Probability methods in Civil Engineering*, NPTEL video lectures. 10. A. Tangirala, *Introduction to statistical hypothesis testing*, NPTEL. 11. A. Kannan, *Statistics of experimentalists*, NPTEL video lectures.

COURSE ARTICULATION MATRIX

PO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**
CO#1	3	3	2	2	1	1	1	-	-	2	2	1
CO#2	3	2	2	1	1	1	1	-	-	-	1	-
CO#3	3	2	2	3	2	2	2	1	-	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO542</td><td>Artificial Intelligence and Soft Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods:
Continuous (CT), mid-term (MT) and End Assessment (EA)</td></tr>
<tr><td colspan="2">Introduction to Computing (CSC01) & Computer Programming Languages like Python, C++, Matlab etc.</td><td colspan="6">CT + MT + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course the student will be able to learn the following:
•CO1: Basics of optimization and soft computing algorithms
•CO2: Learn different soft computing algorithms
•CO3: Learn artificial neural network and its training
•CO4: Study of radial basis function neural and its training
•CO5: Study of machine learning algorithms and clustering</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I. Introduction to Optimization and soft computing algorithms [L-8]
Introduction to optimization, Constrained and unconstrained optimization, Introduction to Optimization based on soft computing, Genetic algorithms, particle swarm optimization
Module II. Review of different soft computing algorithms part-I [L-7]
Flower pollination algorithm, Teaching learning based optimization
Module III. Review of different soft computing algorithms part-II [L-5]
Crow search algorithm, Quantum Particle swarm optimization
Module IV. Basics of artificial neural network and its training [L-7]
Introduction to artificial neural network, Supervised Learning Neural Networks, Perceptrons, Adaline, Multilayer feed forward neural network, Training of neural network using backpropagation algorithm
Module V. Radial basis function neural networks and K-means clustering [L-5]
Radial Basis Function Neural Networks (RBF), Training of RBF using pseudo inverse technique, Data clustering using K-means
Module VI. Study of machine learning algorithms [L-10]
Extreme learning machine (ELM), Training and testing of ELM, Recurrent Neural Network(RNN) and long short-term memory (LSTM),Training a LSTM based RNN, Deep learning and Convolutional Neural Network(CNN).</td></tr>
<tr><td rowspan="2">Text Books, and/or Reference material</td><td colspan="7">Text Books:
1. S N Sivanandam, S.N.Deepa, "Principles of Soft Computing," Wiley,3rd edition,2018
2. Samir Roy & Udit Chakraborty, "Introduction to Soft Computing," Pearson,1st edition,2013
3. Satish Kumar, " Neural Networks: A Classroom Approach", McGraw-Hill (India), 2013
4. Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms, "Cambridge University Press",2014</td></tr>
<tr><td colspan="7">Reference books:
1. S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI,2003
2. Jang, Sun, Mizutani, "Neuro-Fuzzy and Soft computing", Pearson,2015
3. Simon Haykin, "Neural networks and learning machines," Pearson,3rd edition, 2009
4. Charu C.Aggarwal, "Neural Networks and Deep learning,"Springer,2018</td></tr>
</table>

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	2	1	1	2	1	1	1	1	1	1
CO#2	3	3	3	2	2	2	1	1	1	1	1	1
CO#3	3	3	2	2	2	1	2	1	1	1	1	1
CO#4	3	2	2	3	3	2	1	1	1	1	1	1
CO#5	3	2	2	2	2	2	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO540	MEASUREMENTS AND INSTRUMENTATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+MT+EA					
Course Outcomes	• CO1: Given specifications of different measuring instruments for measurement of particular parameter of some known electrical system, compare and judge to find the most suitable one. • CO2: Given application of electrical engineering for measurement of particular parameter along with specified range and accuracy, choose most suitable measuring instrument with the understanding of individual working principles, also judge to fit the given application. • CO3: For some specific parameter to be measured, along with the given range, resolution, accuracy and output format, choose suitable sensor, design associated signal conditioning and analog/digital processing circuit to meet the desired specification. • CO4: Given parameters to identify the location of fault.						
Topics Covered	Method of measurement, Measurement system, Classification of instruments, Definition of accuracy, Precision, Resolution, Speed of response, Error in measurement, Classification of errors. (3) Measurement of Voltage and Current: Principle of operation and torque equation of Moving coil, Moving iron instruments. (5) Extension of instrument ranges. (2) Measurement of Power & Energy: Principle of operation of Electrodynamic & Induction type wattmeter, Power measurement by two wattmeter, Construction, theory and application of AC energy meter. (6) Measurement of resistance: Measurement of medium, low and high resistances, Megger (6) AC Bridges: Measurement of Inductance, Capacitance, Frequency, mutual inductance (8) Localization of Cable fault: Methods used for localization of ground and short circuit fault. (4)						

	Sensors & Transducers: Introduction to sensors & Transducers, Strain gauge, LVDT, Temperature transducers, Piezo-electric transducer, pressure transducer, Flow measurement using magnetic flow measurement. (8)
Text Books, and/or reference material	Text Books: 1. K. Sawhney, A course in Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai& sons. 2. E. W. Golding & F. C. Widdis, Electrical Measurement & Measuring Instruments, Wheeler Publishing Reference Books: 1. H. S. Kalsi, Electronics Instrumentation, Mc-Graw Hill Education. 2. A. J. Bouwens, Digital Instrumentation, Tata Mc-Graw hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	2	2	2	2
CO2	3	2	3	2	2	2	1	1	3	2	1	2
CO3	3	2	3	2	2	2	1	1	2	1	2	1
CO4	3	2	2	2	2	2	2	2	2	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO541	FUNDAMENTALS OF CONTROL SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC01 (MATHEMATICS-I) MAC02 (MATHEMATICS-II)		CT+MT+EA					
Course Outcomes	• CO1: To get the knowledge of basic objectives of control system design • CO2: To derive input-output relationship of systems based on their mathematical modeling governed by basic laws of physics • CO3: To justify stability of systems based on their transfer functions, time domain and frequency domain specifications • CO4: To develop concepts on root pattern with variable gains and comment on the stability • CO5: To determine the stability of closed-loop system based on open loop frequency response • CO6: To be able to design controllers so as to meet design specifications both in time as well as frequency domain • CO7: To be able to realize the controller both in software simulation through MATLAB coding as well as in real-time environment.						
Topics Covered	**Introduction to control systems:** Historical development, Open and Closed loop systems, Applications, Effects of feedback, Types of feedback control systems, Servomechanism. (4) **Mathematical Models of Physical Systems:** Modeling of electrical networks, Modeling of mechanical system elements, Transfer functions, Block diagram Algebra, Signal flow graph and Mason's Gain formula. (6) **Introduction to State Variable Approach:** Concepts of state, state variables and state model state models for linear Continuous-time systems,						

	state transition matrix. (4) Representation of Control Components: Electrical components, Mechanical components, Electromechanical Components. (2) **Time domain analysis and design specification of linear systems:** Standard signals, Transient response and s-plane root locations of Second and higher order systems, Design specifications, steady state errors and error constants, effects of adding poles and zeros to transfer functions, P, PI, PD and PID controllers. (6) **Concepts of Stability and Algebraic Criterion:** Concept of stability, Characteristic equation & necessary conditions for stability, Routh-Hurwitz stability criteria. (4) **Root Locus Technique:** The concept of root locus, Analytical construction of Root Loci, Root-locus Plots with MATLAB. (4) **Frequency Response Analysis and Stability Studies in Frequency Domain:** Frequency domain specifications, correlation between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability, conditionally stable system, M and N loci on complex and gain phase plane, MATLAB tools and case studies. (8) **Design and Compensation Techniques:** Preliminary considerations of classical Design, Realization of Basic compensators, Frequency domain and s-plane design techniques, Example of control systems. Design with MATLAB.(4)
Text Books, and/or reference material	Suggested Text Books: 1. J. Nagrath and M Gopal, Control system Engineering, New Age Intl. Pub. 2. K. Ogata, Modern Control Engineering, Prentice Hall. 3. B. C. Kuo, Automatic Control system, John Wiley & Sons Suggested Reference Books: 1. Norman S. Nise, Control system Engineering, John Wiley & Sons 2. B. Shahian and M. Hassul, Control System Design using MATLAB, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	2	1	3	1	2	2
CO2	3	3	3	3	2	2	2	1	3	1	1	1
CO3	3	3	3	2	2	1	2	2	3	1	1	1
CO4	2	3	2	2	1	1	2	1	2	1	1	1
CO5	3	3	3	2	2	1	3	1	2	1	1	1
CO6	2	3	3	2	3	2	3	1	3	1	1	1
CO7	2	3	3	3	3	3	3	2	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO542	POWER SYSTEM ANALYSIS AND DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Given Specification leads to design of network, choice of optimal Voltage, Transmission line and its material, considering the factors like sag, tension and corona. • CO2: Given Specification leads to study of suitable system parameters and incorporating laws of Power systems to choose the most applicable. • CO3: Given Specification emphasizes on the different Tariff structures, by which one can able to judge, compare and select a suitable Tariff plan. • CO4: Given Specification emphasize on the design of equipment's, on the basis of power factor. • CO5: Given specification will give knowledge about the different types of faults and its severity, which can help to design the protection schemes for those faults
Topics Covered	Fundamentals of Power systems: Transmission line (single phase and three phase), per unit systems, Line constants. (1) Load characteristics: Introduction, connected load, variable Load on Power Station, Load Curves, Important terms and factors, Load duration curve-Load curves and selection of generating units, base load and peak load of power station. (6) Mechanical Design of Overhead Lines, Sag and Tension: General consideration, Line supports, type of steel towers, Sag and tension, Sag and tension calculation, Parabolic method, Catenary method, Sag and tension charts. (7) Corona: Phenomenon of corona, disruptive critical voltage, visual critical voltage, corona loss, factors and conditions affecting corona loss. (3) Balanced and unbalanced fault: Introduction, effects of faults, symmetrical fault, symmetrical components, unsymmetrical faults. (5) Load flow studies: Network model formulation, formation of Ybus, load flow problem, Gauss-Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods. Advantages and disadvantages. (7) Power system stability: Steady state stability, transient stability, equal area criteria, swing equation, multi machine stability concept and methods for improving stability. (8) Economic operation of power system: Incremental fuel cost, economic dispatch neglecting transmission losses, transmission loss as a function of plant generation, General loss formula, Optimum load dispatch considering transmission losses. (5)
Text Books, and/or reference material	Text Books: 1. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, Hodder Arnold 2. 2. A. R. Bergen, V. Vittal, Power Systems Analysis, Pearson Edition Reference Books: 1. John J. Grainger & William D. Stevenson, Power system analysis, Tata McGraw Hill Education. 2. D. P. Kothari & I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Education

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	2	2	1	1	2	2
CO2	3	3	2	2	1	1	1	1	2	1	2	2
CO3	3	2	1	1	1	2	1	2	1	1	1	2
CO4	3	3	2	1	2	1	1	2	1	2	2	1
CO5	3	3	3	2	1	2	1	2	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 541	**Experimental Methods in Engineering**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1: Acquire an idea about basic concepts of engineering measurements CO2: To learn the basics of data analysis CO3: To learn the fundamentals of data acquisition. CO4: To learn the measurement techniques for electrical signals, pressure, temperature, flow, force, motion, vibration etc.						
Topics Covered	• Basic concepts: Calibration, Standards, Dynamic Measurement, System response and Fourier Analysis 4 • Data analysis: Error analysis, Uncertainty analysis, Statistical analysis, Curve fitting, Goodness of fit. 6 • Measurement of electrical signals: Waveform measurements, Analog/digital meters, Amplifiers, Signal Conditioner, Oscilloscope, transducers 5 • Measurements of physical variables: Pressure measurement 4 • Flow measurement 6 • Temperature measurement 4 • Force/ torque/ strain measurement, motion and vibration measurement. 9 • Data acquisition and processing: Signal conditioning, Data transmission, ADC and DAC 4						
Text Books, and/or reference material	**Text Books:** 1. Experimental Methods for Engineers – J. P. Holman **Reference Books:** 1. Instrumentation, measurements and experiments in Fluids by E. Rathakrishnan 2. Handbook of experimental fluid mechanics by Foss et al. 3. Measurement systems—application and design, Doebelin, E. O.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 542	**Introduction to Fluid Mechanics**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	• CO1: Understanding the basic principles of fluid flow. • CO2: Relate the fluid-dynamic involved in single phase flow. • CO3: Plan elementary analysis of most liquid Flow. • CO4: Analyze the model to a wide variety of complex engineering problems. • CO5: Plan elementary analysis of fluid flow systems. • CO6: Conclude the Hydrodynamics flow situations.						

Topics Covered	• **Introduction:** Definition of fluid, Continuum hypothesis, Scope of fluid mechanics, Flow pattern: Streamlines, Streak line and Path line. Differential versus Integral Approach. **(3L)** • **Kinematics of flow:** Lagrangian and Eulerian Approach, Reynolds transport Theorem for integral analysis, Acceleration of Flow, Material derivatives, Angular deformation of a fluid element, Stream-function, Problems. **(4L)** • **Fluid property and governing equation of static and inviscid fluid:** Newtonian Fluid and Non-Newtonian fluids, Surface tension, Euler Equation, Governing equation of statics, Bernoulli's Equation., Problems **(4L)** • **Flow measurement:** Flow measurement by Venturimeter, Orifice meter and Pitot tube, problems. **(3L)** • **Dynamics of viscous flows:** Continuity equation in different coordinates, Navier-Stokes equation and Energy equation. General structure of conservation equations. **(4L)** • **Flow through pipes:** Loss of energy in pipe, loss of energy due to friction (Moody's diagram)), minor losses in pipe, hydraulic and energy gradient line, piping system, flow through branched pipe, power transmission through pipes, problems, problems. **(4L)** • **Boundary layer theory:** Derivation of boundary layer equation, Order-of-magnitude analysis, Flow over flat plate, Separation of boundary layer over a circular shape. Different examples **(7L)** • **Turbulence:** Eddies and vortex shredding, statistical description of turbulent flow, Reynolds stresses, Reynolds averaged Navier stokes equation, Prandlt's mixing length, Wall effect in turbulent flow. **(7L)**
Text Books, and/or reference material	**Text Books:** 1. R. W. Fox,P. J.Pritchard,A. T Mcdonald, Introduction to Fluid Mechanics, John Wiley 2. F. M White, Fluid Mechanics, Tata McGraw Hill Eduction. 3. S K Som, G Biswas,Suman Chakraborty, Introduction to Fluid Mechanics and Fluid machines, Tata McGraw Hill Education.

BASKET - 3

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO740	Indian Writings in English	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Students will develop an understanding of History, Politics, Literature, and the place of English in India with a special emphasis on the pursuit of nuclear weapons in the subcontinent which is the moral equivalent of Civil War.						
Topics Covered	The Course will undertake a detailed study of Amitav Ghosh's *Countdown* with reference to the following topics: 1. History, Politics, Literature, and the Place of English in India (4) 2. Post-Nuclear India (4) 3. Historical Concepts of Indo-Pakistan Relations (4) 4. Thematic Concerns of Amitav Ghosh (4) 5. Ghosh's contribution to Indian Literature (4) 6. Close reading and analysis and discussion of *Countdown* (18) 7. Political struggle in the subcontinent can bring only immeasurable disaster (4)						
Text Books, and/or reference material	Text Book: 1. Countdown—Amitav Ghosh						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	2	2	-	-	-	3

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO 741	Development Economics and Sustainable Development	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	1. Develop an understanding about the basic concepts of Economics and Sustainable Development. 2. Know various Indian economic problems and significance of those for growth and development.
Topics Covered	Unit 1: Economic Growth - (3L) Unit 2: Development I - (3L) Unit 3: Development II - (3L) Unit 4: Problems of Capital Formation I - (3L) Unit 5: Problems of Capital Formation II - (3L) Unit 6: Problems of Capital Formation III - (3L) Unit 7: Institutions and Economic Development I - (3L) Unit 8: Institutions and Economic Development II - (3L) Unit 9: Planning Problems I - (3L) Unit 10: Planning Problems II - (3L) Unit 11: Trade and Development I - (3L) Unit 12: Trade and Development II - (3L) Unit 13: Sustainable Development I - (3L) Unit 14: Sustainable Development II - (3L)
Text Books, and/or reference material	1. Ray, D. (2003), *Development Economics*, New Delhi: OUP. 2. Sen, A. (2001), *Development as Freedom*, New York: Oxford University Press. 3. Thirlwall, A.P. (2005), *Growth and Development*, ELBS. 4. Patil, R. B. (Ed) (2014), *Sustainable Development*, New Delhi: Rawat Publications. 5.Peet, R. (2005), Theories of Development, New Delhi: Rawat Publications.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	2	2	3	3	2	3	3	3	2	2	3	3
CO2	1	3	3	3	2	3	3	3	2	2	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSO742</td><td>Culture and Communication</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To be able to analyze the basic concepts of communication across cultures and investigate the notions of cultural production, cultural identity, cultural difference and global cultural change
CO2: Understanding the process and implications of communication in the development of different cultural groups, subgroups and communities in the era of globalization</td></tr>
</table>

<table>
<tr><td>Topics Covered</td><td>
❖ Introduction to Cultural Studies (5)
❖ Fundamentals of Communication for the Study of Culture: Theories and Principles (5)
❖ Defining Gender, Class, Ideology and Power (4)
❖ Role of Communication in a Global Village (5)
❖ Multiculturalism and Intercultural Communication (5)
❖ Diaspora and Communication (3)
❖ Impact of Popular Culture, Subculture and Counterculture (5)
❖ Social Media, Networking and Cross-Cultural Experiences (5)
❖ Development Communication and Social Change (5)
</td></tr>
<tr><td>Text Books, and/or reference material</td><td>
1. Gudykunst, W. B., & Mody, Bella (Eds.). (2002). Handbook of international and intercultural communication. Los Angeles: Sage Publications.
2. Jandt, Fred E. (2015). An introduction to intercultural communication: Identities in a global community. Los Angeles, CA: Sage Publications.
3. Dasgupta, S., Sinha, D. Chakravarti, S. (2011). Media, gender and popular culture in India: Tracking change and continuity. Thousand Oaks, Calif. : Sage Publications
4. Durham, M. G., & Kellner, D. M. (Eds.). (2009). Media and cultural studies: KeyWorks. Massachusetts: Blackwell Publishers.
5. Mukerji, C., & Schudson, M. (Eds.). (1991). Rethinking popular culture: Contemporary perspectives in cultural studies. CA: University of California Press.
</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	-	-	3	3	-	3
CO2	-	-	-	-	-	2	-	-	3	3	-	3

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PHO741</td><td>Nuclear Reactor Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To understand basic properties of a nucleus and nuclear reaction.
CO2: To procure knowledge of the action of nuclear reactor.
CO3: To understand neutron physics and diffusion theory.
CO4: To learn the utility, protection and control of nuclear reactor.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">General Nuclear Properties:
Nuclear mass, Mass defects, Binding energy, Liquid drop model, Semi-empirical mass formula, Energy losses by charged particles and gamma rays. [6]
Nuclear Reaction:
Types of nuclear reaction, Cross-section of a nuclear reaction, Neutron induced reactions, Nuclear fission, Separation energy and fissionability, Fission cross section for slow and fast neutrons, Energy release in fission, Fission fragments and energy distribution, Nuclear fusion and thermo-nuclear reaction. [6]</td></tr>
</table>

	Neutron Physics and Diffusion Theory: Properties of neutron, Neutron sources, Slowing down of neutrons, Neutron scattering, Moderating ratio, Diffusion of thermal neutrons, Diffusion equation, Slowing down without absorption, Slowing down and diffusion, Critical size of reactors slabs, Cubical, Spherical and cylindrical reactors. Variation of neutron cross-section with neutron energy. [10] **Chain Reaction & Fuel Cycle:** Criticality factor, Moderating ratio, Four-factor formula, Reactor kinetics, Reactor poisons, Nuclear fuel cycle, Enrichment of uranium, Back end of fuel cycle. [6] **General Features of a Nuclear Reactor:** Classification of reactors, Basic components. Outlines of BWR, PWR, GCR and FBR with their basic features and characteristics. [6] **Nuclear Reactor Materials:** Fuel fabrication, Moderators, Heavy water production, Control elements, Structural materials. Reactor protection and control. [8]
Text Books, and/or reference material	**TEXT BOOKS:** **1.** Nuclear Reactor Engineering, Glasstone & Sesonske. **2.** Atomic & Nuclear Physics, S. N. Ghoshal. **3.** Nuclear & Particle Physics, S. L. Kakani, S. Kakani. **REFERENCE BOOKS:** 1. Introduction to Nuclear Reactor Theory, J. R. Lamarsh. 2. Nuclear Physics, I. Kaplan. 3. Nuclear Energy, David Bodansky. 4. Nuclear Physics, D. C. Tayal.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHO 741	CO1	3	1	1	2	1	1	2	1		1		2
	CO2	3	3	1	2		1	2	2		1		3
	CO3	3	3	2	2		2	2	1		1		2
	CO4	3	3	3	3	1	3	3	3		1	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	GENETIC ENGINEERING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	**CO1:** Students will acquire basic understanding of molecules of life and their basic chemistry. **CO2:** Students will acquire knowledge of how genetic material stores programs of life and how that information is retrieved. **CO3:** Students will acquire knowledge of basic tools of genetic engineering and their applications. **CO4:** Students will be able to apply the acquired knowledge in understanding and solving biotechnology issues surrounding us.
Topics Covered	1. Structures of macromolecules such as Carbohydrates, Proteins, Enzymes, Lipids and Nucleic Acids. [10] 2. Basics of cell biology, prokaryotes vs. eukaryotes, sub-cellular structures, their organization and functions. [10] 3. Central Dogma of molecular biology, DNA Replication, Transcription, Reverse Transcription, Translation. [10] 4. Basic tools of nucleic acid manipulation. Methods of genetic engineering; Genetic engineering of microbes, plants and animals. [12]
Text Books, and/or reference material	Suggested Text Books: 1. Essential Cell Biology, 4th Edition, Albertset. al. 2. Biotechnology.2nd Edition, 2015. David Clark and Nanette Pazdernik.Academic Cell. 3. Cecie Starr, Christine A. Evers, Lisa Starr. Biology: Today and tomorrow with physiology. Suggested Reference Books: 1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, Molecular Biology of the Cell, Garland Science. 2. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											1
CO2	2											1
CO3	2						2	2				1
CO4		1	1			2						1

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO740	**Mechanics of Composite**	**Program Elective (PEL)**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Knowledge of Solid Mechanics, Structural	Continuous (CT) and end assessment (EA). CT+EA

Analysis & Design	
Course Outcomes (COs) :	· CO1: Development of skills of finding out mechanical properties of composite materials as well as predicting structural behaviour of composites under different loads. · CO2: Knowledge of basics of analysis and design of structural components, made of variety of composite materials. · CO3: Knowledge of using numerical tools for modeling and analysis of simple structural components
Topics Covered (Hrs)	- Introduction, Types of composite materials, Lamina and Laminate, Matrix and Fibre, Fibre-reinforced Composites, Comparison of strengths between bulk material and fibres. **(6)** - Co-ordinate systems, Effect of orientation of fibres on the strength and stiffness of Composites. **(6)** - Brief outline of manufacturing processes. **(4)** - Micromechanics and Macro mechanics, Constitutive relations, Stresses and Strains, Failure criteria of composites. **(8)** - Analysis of Composites: beams and plates **(12)** - Finite Element Method in analysis of Composite Structures **(6)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Mechanics of Composite Materials by Robert M. Jones: Taylor and Francis (2015) 2. Mechanics of Composite Structures by Autar K. Kaw, Taylor and Francis (2006) ***Reference Books:*** 3. Mechanics Of Composite Materials and Structures by Madhujit Mukhopadhyay, University Press (2004)

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	-	-	-	-	-	-	-	-	-
CO3	-	2	-	-	3	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO741	**Optimization in Engineering Design**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes	· CO1: Develop optimization models for any engineering system. · CO2: Solve optimization problems. · CO3: To learn about modern optimization methods
Topics Covered	**Introduction:** Model, Steps in modeling: Formulation, Deduction, Interpretation, Ten Principles of Modeling, Design Process, Differences Between Engineering Analysis and Design, Comparison Between Conventional Design and Optimal Design. **(4)** **Introduction to optimization model formulation in engineering design:** Objective & Constraint function, Development of objective & constraint functions, Example formulations, Classification of optimization models**. (4)** **Solution Techniques:** Linear programming: Linear Programming Problem, Graphical Solution, Linear Programming in Standard Form, Handling Inequality Constraints, Handling Variables Unrestricted in Sign, Basic Definitions in LP, Canonical reduction, Principles of the Simplex Method, Simplex Method in TABLEAU Form, Computational Problems, Big M Simplex Method, Two-Phase Simplex Method. Revised Simplex Method, Integer Programming, Fixed Charge Problem Formulation. **(8)** **Nonlinear programming – 1:** Single variable unconstrained minimization, Basic Definitions, Optimality Criteria, Introduction to line search techniques**. (4)** **Nonlinear programming – 2:** Multivariable unconstrained optimization, Optimality Criteria, Introduction to various Algorithms for Minimization. **(4)** **Nonlinear programming – 3:** Multivariable constrained optimization, Equality Type Constraints, Lagrange Multiplier, Inequality type Constraints, Optimality Criteria Transformation Methods, Penalty Function Algorithm, Introduction to Linearization Methods, Introduction to Reduced Gradient Method, Introduction quadratic programming, Introduction to projected augmented Lagrangian Method. **(10)** **Introduction to Advanced topics:** Dynamic & Geometric programming, Chance constrained & Multiple objective optimization, Soft computing techniques - Genetic Algorithm, Simulated Annealing Technique, Fuzzy logic, Artificial Neural Networks. **(8)**
Text Books, and/or reference material	***Text Books:*** 1. Engineering Hydrology by R. S. Varshney, Nem Chand & Bros. Roorkee (U.P.) 1986. 2. Operations Research – Principles and Practice by A. Ravindran, D. J. Philips and J. J. Solberg, 2nd Ed., John Weley & Sons, New York, 1987. 3. Engineering Optimization – Theory and Practice by S. S. Rao, 3rd Edition, New Age Int. (P) Ltd. Publishers, New Delhi, 2001. ***Reference Books:*** 4. Nonlinear Programming – Theory and Algorithms by M. S. Bazaraa & C. M. Shetty, John Wiley & Sons, New York, 1990. 5. Introduction to Optimum Design by J. S. Arora, McGraw Hill Int. Editions, McGraw Hill Book Co. Singapore, 1989.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	3	3	-	-	-	-	-	-	-	-	-
CO2	-	3	3	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO742	**Theory of Elasticity and Plasticity**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisites:	Course Assessment methods
Engineering and Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	· CO1: To develop basic understanding of the behaviour of materials. · CO2: To define the stress and strain behaviour of structural elements. · CO3: To apply theory of elasticity in bending and torsion problems. · CO4: To apply theory of plasticity in failures of different materials and structures.
Topics Covered	**Stress & Strain**: Stress equilibrium equations, rectangular, cylindrical and spherical co-ordinates, Generalized Hooke's Law, Stress and strain compatibility equations. Plane stress and plane strain problems, Airy's stress function, Principal Stresses and strains, stress & strain invariants, numerical problems. **(15)** **Torsion**: Shafts of circular and non-circular prismatic sections, Saint Venant theory, warping function, stress function. **(7)** **Theories of Failure**: Basic concepts and Yield Criteria, Different Theories of Failure, Yield Locus and Yield Surfaces. Equations of Plasticity. **(8)** **Plasticity**: hydrostatic stresses, deviatoric stresses, invariants of deviatoric stresses, yield criteria, von Misses, Tresca yield criteria, theories of plastic flow, plane stress, plane strain problems in plasticity, thick cylinders, thick spheres. **(12)**
Text Books, and/or reference material	***Text Books:*** 1. Theory of Elasticity and Plasticity by S. Timoshenko, MC Graw Hill. 2. Theory of Elasticity and Plasticity by Sadhu Singh, Khanna Publishers. ***Reference Books:*** 3. Advanced Strength of materials by Papov, MC Graw Hill Book Company. 4. Plasticity for structural Engineers by W. F. Chen and D. J. Han, Springer-Verlag, New York.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO 9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	3	2	2	-	-	-	-	-	-	-	-

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO741	**NON-LINEAR DYNAMICS**	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To understand the physics of dynamic complexity of a nonlinear process • CO2: To identify strange attractors and to estimate their degree of complexity • CO3: To learn relevant mathematical methods for solving nonlinear problems						
Topics Covered	**Module I:** Theories of ODEs: First-order ordinary differential equations, basic ideas. Definitions of stability and elements of linear algebra. Stability of homogeneous linear systems, fundamental stability theorem for nonlinear systems. Uniqueness Conditions for Linear and Nonlinear Systems [10 hrs.] **Module II:** Periodic solutions and Bifurcations: Phase portraits; Hopf bifurcations; period doubling; Poncare maps; RuelleTakens scenario; Floquet matrices and stability. Maps; Reduction of flows to maps; Reconstruction of phase space from one-dimensional signals. [11 hrs.] **Module III:** Quantitative analysis of strange attractors: Liouville's theorem and conservation of areas in phase space; Sensitivity to initial conditions; Stretching and folding;.Lyaponov exponents; Fractal dimension; power spectrum, Lyapunov exponents and Lyapunov functions [11 hrs.] **Module IV:** Case studies: Logistic equation, Lotka-Volterra predator-prey mechanism, Oscillating Chemical Reactions: Brusselator and Oregonator, Lorenz and Rössler attractors, adiabatic and nonadiabatic CSTRs, fermenters, boiling flows, etc. [11 hrs.]						
Text Books, and/or reference material	Suggested Text Books: 1. Pushpavanam, S., Mathematical Methods in Chemical Engineering, PHI Learning 2. Strogatz, S. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering, Westview Press; 2nd edition (2014) Suggested Reference Books: 1. Robert Hilborn, Chaos and nonlinear dynamics : An introduction for scientists and engineers						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1	1							
CO2	3	2	1	1	1						1	
CO3	3	2	1	1	1						1	

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO741	Software Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Identify and describe software life cycle model and their roles in building software project. • CO2: Recognize the feasibility of functional and non-functional requirements applying decision tree/table minimization techniques/methodologies for a particular problem. • CO3: Apply modularity in project resulting design of flexible software code with reusability. • CO4: Effectively use existing testing strategy to test the software and make sure the reliability of the software and analysis of quality of the software. • CO5: Apply the project management tools, estimation techniques to handle the project.						
Topics Covered	**UNIT I:** Overview of System Analysis & Design, Software Development Life Cycle, Waterfall Model , Spiral Model, Feasibility Analysis, Technical Feasibility, Cost- Benefit Analysis, COCOMO model. [10L] **UNIT II:** System Requirement Specification – DFD, Data Dictionary, ER diagram, Process Organization & Interactions. [10L] **UNIT III:** System Design – Problem Partitioning, Top-Down And Bottom-Up design; Decision tree, decision table and structured English; Functional vs. Object- Oriented approach. [10L] **UNIT IV**: Coding & Documentation - Structured Programming, OO Programming, Information Hiding, Reuse, System Documentation. Testing – Levels of Testing, Organizing for software testing; Software Testing Strategy; Unit Testing: Unit Test Considerations; Integration Testing, OO testing, Reliability Assessment, Validation & Verification Metrics, Monitoring & Control. [8L] **UNIT V:** Software Project Management– Project Scheduling, Staffing, Software Configuration Management, Quality Assurance, Project Monitoring. [4L] CASE TOOLS : Concepts, use and application.						
Text Books, and/or reference material	**Text Books:** 1. Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill. 2. Ian Sommerville, Software Engineering, Pearson. **Reference Books:** 1. Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India. 2. Pankaj Jalote, An integrated approach to Software Engineering, Springer/Narosa.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	1	1	1	2	1	2	2
CO2	3	3	1	2	2	1	1	1	2	1	2	1
CO3	2	3	2	2	2	2	2	-	2	2	2	2
CO4	1	1	3	3	3	1	1	1	2	2	-	-
CO5	1	2	3	3	3	1	1	1	2	2	2	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Cred it
			Lectur e (L)	Tutori al (T)	Practical (P)	Total Hour s	
CSO 742	**Multimedia Technologies**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Knowledge of data structures databases and compression techniques	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**

Course Outcomes	• CO1: In depth understanding of media characteristics and resource requirement. • CO2: Understanding text, graphics. Audio, video media types. • CO3: Knowledge of issues on dealing simultaneously with multiple data formats, temporal and spatial constraints, synchronization aspects, SAS factors. • CO4: Understanding of data compression techniques of different media. • CO5: Understanding of multimedia database storage and retrieval.
Topics Covered	Overview of multimedia system: Text, audio, video and graphics. (3L) Video and Animation: Capturing Graphics and Images Computer Assisted Graphics and Image Processing; Reconstructing Images; Graphics and Image Output Options. Basics; Television Systems; Digitalization of Video Signals; Digital Television; Basic Concepts; Virtual Reality, Video signal representation, Computer Video Format, Computer- Based animation, Animation Language, Methods of controlling Animation, Display of Animation, Transmission of Animation. (10L) Information representation, media synchronisation, SAS factors, relative and absolute temporal specifications, networking delays, Skew, Jitter. (6L) Data Compression: Storage Space requirement, Coding Requirements Source, Entropy Coding, Lossy Sequential DCT- based Mode, Expanded Lossy DCT-based Mode, JPEG and MPEG. (8L) Multimedia file systems: Difference of MM file systems with traditional systems, disk management, disk scheduling, common scheduling algorithms. (5L) Multimedia databases, multimedia query types, index structures to handle multimedia databases, data storage and retrieval. (10L)
Text Books, and/or reference material	**Text Books:** · Multimedia: Computing, Communications and Applications, Ralf Steinmetz and Klara Nahrstedt, Pearson Education Asia. · Multimedia Communications, Applications, Networks, Protocols and Standards, Fred Halsall, Pearson Education Asia. · Multimedia Systems, John F. Koegel Buford, Pearson Education Asia. **Reference Books:** · Subrahmanian and Jajodia, Multimedia Database Systems, Springer.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12
CO1	2	3	3	2	2	3	3	1	1	3	2	3
CO2	3	3	3	2	3	3	3	1	2	3	2	3
CO3	3	3	3	2	3	3	3	1	2	3	2	3
CO4	3	3	3	2	3	3	3	1	2	3	2	3
CO5	3	3	3	2	3	3	3	1	2	3	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 743	Computer Networks	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Fundamental knowledge in Data Structures		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understand the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model. • CO2: Comprehend the fundamentals of Physical layer, and will apply them in real time applications. • CO3: Identify data link layer concepts, design issues, and protocols. • CO4: Classify the routing protocols and analyze how to assign the IP addresses for the given network. • CO5: Acquire knowledge of Application layer and Presentation layer paradigms and protocols.						
Topics Covered	**Introduction:** Data communications: components, data representation, direction of data flow; physical structure (type of connection, topology), categories of network (LAN, MAN, WAN); Protocols and standards; Reference models: OSI reference model, TCP/IP reference model. [3L] **Physical Layer:** Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus. [5L] **Data link Layer:** Types of errors, error detection & correction methods; framing, Flow control Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, Medium Access sublayer: Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA. [10L] **Network layer:** Internetworking & devices, Addressing: IP addressing, subnetting; Routing : techniques, static vs. dynamic routing , Unicast Routing Protocols, Congestion Control and Quality of service (QoS). [12L] **Transport layer:** Process to Process delivery; Socket address,UDP; TCP. [5L] **Application Layer:** Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW. [5L] **Network Security :** Encryption/and decryption algorithms, authentication, access control, Security standards - IS/ISO 27000, 18000 introduction. [2L]						
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan – "Data Communications and Networking (3rd Ed.) " – TMH. 2. A. S. Tanenbaum – "Computer Networks (4th Ed.)" – Pearson Education/PHI. 3. W. Stallings – "Data and Computer Communications (5th Ed.)" – PHI/ Pearson Education. **Reference Books:** 1. Comer – "Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.)" – Pearson Education/PHI.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	1	1	1	1	2	2	2
CO2	2	2	1	1	1	1	1	1	1	1	2	2
CO3	2	2	3	2	2	1	1	1	1	1	1	2
CO4	3	3	3	3	2	2	2	1	1	2	2	2
CO5	2	2	2	2	2	1	1	2	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO744	Computational Biology and its Applications	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and End assessment (EA))					
Introduction to Computing, Linear Algebra, Fundamentals of Probability and Statistics							
Course Outcomes	• CO1: To develop the problem solving skill using the concept of algorithms • CO2: To understand different computational algorithms including few clustering and classification techniques and genetic algorithm. • CO3: To aware the basic principles and concept of Biology and identify the potential application areas. • CO4: To correlate the computational algorithms and the applicable biological domain. • CO5: To develop new computer modelling for different types of biological data						
Topics Covered	1) Algorithms in Computing: Algorithms, Pseudocode, Time & Space Complexity, Dynamic Programming. (4) 2) Pattern Matching and Optimisation: Hashing, Pattern Finding using Clustering, Genetic Algorithms, Evolutionary Computation Techniques, Case Study on GA based feature selection on microarray gene expression (8) 3) Hidden Markov Model: Markov process and Models, HMM applications (6) 4) Support Vector Machine: Introduction, Margin, Hyperplane, Classification. Bayes Theorem, Bayes Classifier. Case Study on Disease Classification(6) 5. Artificial Neural Network: Perceptron, Hidden Layers, Activation Functions, Feed Forward Neural Network and Back Propagation, Case Study on Biological						

	Image Classification (6) 6) Basics of Biology: Central Dogma of Molecular Biology, Molecular Visualisation Softwares, Protein Sequence and Structure Analysis, Protein Structure Modelling, Protein-protein Docking, Genomics. (12)
Text Books, and/or reference material	**References:** 1. An Introduction to Bioinformatics Algorithms, Neil C. Jones, Pavel Pevzner, MIT Press. 2. Bioinformatics: the Machine Learning Approach, Pierre Baldi, Soren Brunak MIT Press. 3. Genetic Algorithms in Search, Optimization and Machine Learning, David E. Goldberg.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	2	1	1	1	-	-	1	1
CO2	2	3	3	3	2	1	1	1	-	-	1	2
CO3	2	3	3	3	2	1	1	1	-	-	1	2
CO4	2	3	3	3	2	1	1	1	-	-	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO740	Biomedical Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO 1**: Understand concept of Biomedical Instrumentation • **CO 2**: Understand basic building blocks of Biomedical Instruments • **CO 3**: Apply quantitative analysis techniques to Biomedical Instruments • **CO 4**: Learn design techniques of Biomedical Instruments • **CO 5**: Investigate application specific Biomedical Instruments						
Topics Covered	**Module I: Introduction to Biomedical Measurements and Instrumentation [L-1]** **Module II: Static and dynamic characteristics of Biomedical Instruments [L-7]** Static characteristics of elements, Dynamic characteristics of elements, Quasi-static characteristics of elements, Static characteristics of systems, Dynamic characteristics of systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth						

	Module III: Error and Noise in Biomedical Measurements [L-4] Sources of noise in measurement systems, mathematical modelling of noise, environmental effects, Effects of Interfering and Modifying inputs, Error analysis, Systematic error, Random error. Statistical methods for noise and error analysis and Modelling. **Module IV: Reliability analysis of Biomedical Instruments [L-4]** Concept of Reliability, Reliability of measurement systems, Reliability enhancement strategies **Module V: Operation of Physiological organs, Bioelectric Potentials and Electrodes [L-7]** Operation of Physiological organs, Operation of Nerves system, Operation of heart, Operation of lungs, Operation of Muscular system, Sources of bioelectric potentials, Bioelectric electrodes **Module VI: Building blocks of Biomedical Instruments [L-9]** Bioelectric sensors, Sensors, Signal conditioning circuits, Bridge circuits, Amplifiers, Filters, Oscillators, ADC, Signal Processing Units, Microcontrollers, Data Presentation elements **Module VII: Application Specific Biomedical Instruments [L-10]** Clinical thermometer, Sphygmomanometer, Digital Statoscope, ECG signal measuring instrument, EEG signal measuring instrument, Medical Imaging techniques, Assistive Respiratory system
Text Books, and/or reference material	**Text Books:** 1. John G. Webster, *Medical Instrumentation Application and Design*, 4ed, Wiley, 2015 2. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 3. R.S. Khandpur, *Handbook of Biomedical Instrumentation*, 3rd Edition, McGraw Hill Education;, 2014 **Reference Materials:** 1. Research Articles

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	2	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	1	3	-	-	-	-	-	-	-	-	-	-
CO#4	2	1	2	-	-	2	-	-	-	-	-	-
CO#5	1	1	1	3	-	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO741	Embedded Systems	PEL	3	0	0	0	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO1:** Understand use of Microprocessor in Microcontrollers and Microcomputer • **CO2:** Interface I/O devices with Microprocessor in Microcontrollers and Microcomputer • **CO3:** Design software controlled hardware systems • **CO4:** Investigate application specific embedded systems						
Topics Covered	**Module I: Intel 8051 Microcontroller [L-4]** Architecture of Intel 8051 Microcontroller using functional blocks, Crystal oscillators, Digital I/O Pins, Digital I/O ports, 8051 Microcontroller programmer, limitations of Intel 8051 Microcontroller. **Module II: ATmega Microcontrollers and Arduino [L-4]** Architecture of ATmega Microcontrollers using functional blocks, Hardware components of Arduino boards, ADC, Analog input pins, Digital I/O pins, PWM signals, PWM pins, Serial communication pins, Arduino shields, Limitations of ATmega Microcontrollers and Arduino. **Module III: Raspberry Pi Micro-Computer [L-4]** ARM processor, Hardware components of Raspberry Pi Micro-computer, GPIO pins in Raspberry Pi board, PWM signals, Raspberry Pi OS, In-built data communication devices, Limitations of Raspberry Pi Micro-Computer. **Module IV: I/O devices for Micro controllers and Microcomputers [L-5]** Sensors, Resistive sensors, Capacitive sensors, Inductive sensors, Actuators, Motors, Signal conditioning circuits, Amplifiers, Filters, Display elements, Data storage devices, Compatibility of several transducers with Intel 8051 Microcontroller, ATmega Microcontrollers and Arduino, Raspberry Pi Micro-Computer **Module V: Embedded System Programming using Keil [L-7]** Keil editor and compiler, Keil Programming for Intel 8051 Microcontroller, Program uploading to 8051 Microcontroller, I/O programming, Interfacing Analog and Digital sensors and actuators with Intel 8051 Microcontroller, Interrupt programming in 8051, Keypad and Display element interfacing with 8051. **Module VI: Embedded System Programming using Arduino language [L-7]** Arduino editor and compiler, Arduino Programming, Program uploading to Arduino board, I/O programming, Interfacing Analog and Digital sensors and actuators with Arduino, Serial communication and Data transmission in Arduino, Interrupt programming in Arduino, Keypad and Display element interfacing with Arduino. **Module VII: Embedded System Programming using Python [L-7]** Raspberry Pi OS, Python programming, Interfacing Analog and Digital sensors and actuators with Raspberry Pi, I/O programming in Raspberry Pi, Serial						

	communication and Data transmission in Raspberry Pi, Interrupt programming, Keypad and Display element interfacing with Raspberry Pi. **Module VIII: Case studies [L-4]** Application specific embedded system design using 8051 Microcontroller, Arduino, Raspberry Pi, Password lock device using Embedded system, Smart home using embedded system, Motor controller using Embedded system
Text Books, and/or reference material	**Text Books:** 1. T. Givargis, F. Vahid , *Embedded System Design: A Unified Hardware / Software Introduction*, Wiley; Student edition, 2006 2. E. A. Lee, S. A. Seshia*, Introduction to Embedded Systems - a Cyber Physical Systems Approach*, PHI Learning Pvt Ltd, MIT Press; Second edition, 2019 3. M. A. Mazidi, *The 8051 Microcontroller and Embedded Systems: Using Assembly and C*, Pearson Education India; 2nd edition, 2007 **Reference books:** 1. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 2. T. W. Schultz, *C and the 8051, Vol.I: Hardware, Modular Programming & Multitasking*, Prentice Hall; 2nd edition, 1997 3. S. Monk, *Programming Arduino: Getting Started with Sketches*, Second Edition, McGraw-Hill, 2nd edition, 2016 4. J. Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, Newnes; 3rd edition, 2013 5. S. Monk, *Raspberry Pi Cookbook: Software and Hardware Problems and Solutions,* Shroff/O'Reilly; Second edition, 2016 6. D. Molloy, *Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux*, Wiley; 1st edition, 2016 7. Research Articles

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	2	-	-	-	-	-	-
CO#2	3	1	-	-	-	-	-	-	-	-	-	-
CO#3	1	3	-	1	-	-	-	-	-	-	-	-
CO#4	1	1	-	3	-	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO742	Mobile Communication	PEL	3	0	0	3	3
Prerequisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):					
NIL		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					

Course Outcomes	**CO1:** Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints. **CO2:** Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium. **CO3:** Analyze and design receiver and transmitter diversity techniques. Evaluate the data rate performance. **CO4:** Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel **CO5:** Describe and differentiate five generations of wireless standard for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA); 4G (OFDM) and 5G technologies
Topics Covered/ Syllabus	**Module I. (L - 5)** Introduction to Wireless Personal Communication, Mobile radio systems. **Module II. (L - 10)** Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, Call blocking, Cell splitting and Directional antenna etc. **Module III. (L - 8)** Characterization of wireless radio channel, propagation path models. Fading and Shadowing. **Module IV. (L -12)** Receiver Techniques for fading Channel. Detection of Signal in Fading Channel, Receive Diversity, Transmit Diversity, Equalization, Fading mitigation. Modulation schemes for wireless Communication (MSK, GMSK), OFDM, Multiple access techniques: Spread spectrum techniques, Cellular CDMA, NOMA **Module V. (L - 7)** Wireless Networks and Standards: GSM, CDMA Cellular standard, 3G, 4G
Text Books, and/or Reference material	**Text Books:** [1] Andrea Goldsmith, "*Wireless Communication*", Cambridge University Press [2] Aditya K Jagannathan, "*Principles of Modern Wireless Communication Systems Theory and Practice*", McGraw-Hill India. [3] David TSE and Pramod Viswanathan, "*Fundamentals of Wireless Communication*", Cambridge University Press **Reference Books:** [1] Theodore Rappaport, "*Wireless Communications: Principles and Practice*", Pearson, 2nd Edition [2] Andreas. F. Molisch, "*Wireless Communication*", John Wiley and Sons [3] Mark and Zhuang, "*Wireless Communication and Networking*", PHI

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	3	3	1	1	-	-	-	-	-	-	-
CO#2	3	3	3	1	1	-	-	-	-	-	-	-
CO#3	3	3	3	1	1	-	-	-	-	-	-	-
CO#4	3	3	3	2	1	-	-	-	-	-	-	-
CO#5	3	3	3	2	2	-	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 43				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO743	Internet of Things	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous (CT), Mid-Term (MT), End Assessment (EA)					
NIL		CT+MT+EA					
Course Outcomes	**CO1**: Explain the term IoT and understand the main components of IoT systems. **CO2**: Recognize, interpret and apply a variety of enabling technologies, connectivity technologies and communication protocols that occur in IoT systems. **CO3**: Design and analysis of a complete working IoT system involving prototyping, programming and data analytics						
Topics Covered	**1. Introduction to IoT**: Introduction and definition of IoT; -Basics of networking: Network types; Network topologies; OSI model; Adressing TCP/IP; -Predecessors of IoT: WSN; M2M; Cyber Physical Systems **(5L)** **2. IoT enabling technologies**: **(8L)** - Cloud computing; Big data analytics; Embedded systems; -IoT levels: level 1 to level 6 -Introduction to sensors; actuators; microcontrollers, and their interfacing: Sensors-characteristics, types; Sensor interfacing-interfacing gas sensors with nodeMCU/ Arduino, interfacing pH sensor, interfacing pulse sensor. -Actuators: types, functions -Microcontrollers and overview **3. IoT communication technologies:** -Constrained nodes and networks: types; lossy and low power networks -Protocols for messaging and transport: Messaging protocols- MQTT; CoAp; XMPP; DDS -Protocols for addressing and identification: IPV4; IPV6; Uniform Resource Identifier (URI); 6LoWPAN; Discovery protocols like universal plug and play; multicast DNS. **(6L)** **4. IoT connectivity technologies:** IEEE 802.15.4; Zigbee; RFID; NFC; Sigfox; LoRa; NB-IoT; WiFi; Bluetooth **(2L)** **5. Cloud for IoT**: challenges; selection of cloud service provider; introduction to Fog computing- working principle; edge and Fog computing; security aspects. **(2L)** **6. Data analytics**: Data analysis; Machine learning: supervised and unsupervised; Types of ML models: classification; regression; clustering; Model building process; modeling algorithm; model performance; Big data platform. **(5L)** **7. IoT case studies and future trends**: Agricultural IoT; Vehicular IoT; Healthcare IoT; Evolution of new IoT paradigms- IoBT; IoV; IoNT; IoD; IoSpace; NFV; SDN; 5G as IoT enabler. **(6L)** **8. IoT hands on:**-Home automation: smart lighting;Air pollution monitoring;Health care: elderly fall detection; Prevention of drowsiness of drivers by IoT based smart drivers assistance systems. **(9L)**						
Text Books, and/or reference material	**Text Books**: 1. Shriram K Vasudevan; Abhishek S Nagarajan; RMD Sundaram, *Internet of Things*, 2nd Edition, Wiley, New Delhi, 2020. 2. S. Mishra, A. Mukherjee, A. Roy, *Introduction to IoT*, 1st Ed., Cambridge						

	University, UK, 2021. **Reference Books**: 3. A. Bahga, V. Madisetti, *Internet of Things: A Hands-on approach*, 1st Ed., Universities Press (India) Pvt. Ltd., Hyderabad, 2014. 4. K. N. Raja Rao (editor), *Internet of Things: Concepts and Applications*, 1st ed., Wiley India, 2021.

COURSE ARTICULATION MATRIX

PO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2
CO#2	3	2	2	2	2	1	1	-	-	1	1	2
CO#3	3	2	3	3	3	2	2	1	-	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO740	CONCEPT OF ELECTRICAL MACHINES & DRIVES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO 1: Get an introductory draft of electrical drive system and discuss different drive systems stability based on fundamental torque equations. • CO2: Explore the motoring principle and design of different parameters of DC and AC motors. • CO3: Calculate different parameters of starters and breakers for DC and AC drive system and know about different starting and braking techniques. • CO4: Understand multi-quadrant operation of DC and AC drive systems and the speed torque characteristics. • CO5: Recognize different speed control techniques of DC and AC drives and compute different speed control system parameters.						
Topics Covered	Concept of electrical drives; Classification, group, individual, multi-motor electric drives; Classification of control schemes and components of electric drives, closed loop control of industrial drives. (6) Speed-Torque characteristics of dc drives; Basic parameter, types of loads, quadrant diagram. Speed-Torque characteristics of dc shunt and series motor. Types of starters and braking (dynamic, regenerative braking) of dc drive. (8) Speed control of dc motor: Basic parameters, method of speed control of dc shunt and series motor. Speed control of dc series motor in a crane using dynamic braking. Introduction to soft control of dc drive. (8) Induction Motor Drives: Three phase I.M., analysis and performance. Operation with unbalanced source voltages and single phasing, analysis						

	of I.M. fed from non-sinusoidal voltage supply. Starting, Braking. Speed control methods of IM, v/f-controlled induction motors, controlled current and controlled slip operation and its application. (12) Stepper, universal, servo and switch reluctance motor drives, solar and battery powered drives, Energy conservation in Electrical Drives. (5) Industrial application of electrical drives: Electric traction, paper mill, textile mill, and coal mines. (3)
Text Books, and/or reference material	Text Books: 1. G. K. Dubey, Fundamentals of Electrical Drives, Narosha Publishing House, 2001. Reference Books: 1. N. K. De and P. K. Sen, Electric Drives, PHI, 2001.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	2	1	1	1	1
CO2	3	3	3	3	3	3	2	2	1	1	1	1
CO3	3	3	3	3	2	2	2	1	1	1	1	1
CO4	3	3	3	2	3	2	2	1	1	1	1	1
CO5	3	3	3	2	2	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO741	BIOMEDICAL INSTRUMENTATION!	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO 1: Familiarization with biomedical equipment's and transducers • CO2: Introduction to biomedical signal conditioners • CO3: Acquiring knowledge about development of bio potentials and their measurements. • CO4: Introduction patient health care monitoring • CO5: Introduction to computerized imaging techniques
Topics Covered	Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits. (8) Various types of signal conditioners, signal conditioning processes. (8) Generation of Nernst Potential, Establishment of diffusion potential, Goldman Equation, Measurement of membrane potential, resting potential, action potential. (6) Use of electrodes for measurement of bio potentials, polarization in electrodes, principle of operation of Ag/AgCl electrode, Equivalent circuit of electrode. (6) Measurement of ECG, Einthoven triangle method, unipolar and bipolar limb leads, ECG amplifiers, Problems encountered in ECG recording. (6) Introduction to medical imaging, Radiography, Computerized tomography, X Ray, -CT, MRI. (8)

Text Books, and/or reference material	Text Books: 1. John Enderle. Joseph Brinzino, Introduction to Biomedical Engineering, Elsevier, 2012. 2. John G Webster, Medical Instrumentation, Application & Design, John Wiley & Sons, 2009 Reference Books: 1. L. Cromwell, Fred J. Weibell, Erich A. Pfeiffer, , Biomedical Instrumentation & Measurements, PHI, 2014 2. Arthur C Guyton, John E Hall, Textbook of Medical Physiology, Elsevier, 2006:

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	1	3	1	1	2
CO2	3	3	3	3	3	3	1	1	3	1	1	2
CO3	3	3	3	3	3	3	1	1	3	1	1	2
CO4	3	3	3	3	3	3	1	1	3	1	1	2
CO5	3	3	3	3	3	3	1	1	3	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO742	RENEWABLE ENERGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC01 (ELECTRICAL TECHNOLOGY)		CT+MT+EA					
Course Outcomes	• CO1: To understand the basics of Energy System and overall energy resources • CO2: To design the solar and wind power plant • CO3: To understand the tidal, geothermal energy, biomass and other resources and principles • CO4: To understand the energy conservation opportunities and energy saving						
Topics Covered	Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission. (9) Solar photovoltaic: Introduction, solar radiation & its relationship with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors: -materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments. (8) Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind						

	generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. (6) Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. (4) Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects. (5) Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid. (5) Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics. (5)
Text Books, and/or reference material	Text Books: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003. 2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. 3. Fuel Cell Handbook, Parsons Inc. 4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**2**	**1**		**1**	**1**	**1**			**1**	**1**
CO2	**3**	**3**	**2**	**1**	**1**	**1**	**1**				**1**	**1**
CO3	**2**	**3**	**3**	**2**	**1**	**1**	**1**	**1**	**1**		**1**	**1**
CO4	**2**	**3**	**3**	**2**		**1**	**1**	**1**	**1**		**2**	**1**

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO743	FLIGHT CONTROL SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CONTROL SYSTEMS (EEC431) FUNDAMENTALS OF CONTROL SYSTEMS (EEO541)		CT+MT+EA					
Course Outcomes	• **CO1:** To develop the concept of the aerodynamics, 6 degrees of freedom motion of aircraft and understanding the role of control surface. • **CO2:** To understand the longitudinal and lateral dynamics of aircrafts and						

	to identify different modes along with the scope of their improvements by designing control law. • **CO3:** To develop the concept of Static and Dynamic Stability of Aircrafts. • **CO4:** To develop insight on margin criterion, the closed loop response specifications and their relationship with the stability and flying qualities of the aircrafts. • **CO5:** To design control law based on Classical Control Theory for Longitudinal and Lateral/directional dynamics to meet the desired margin and flying qualities criteria • **CO6:** To design control law based on Classical Control Theory for Longitudinal and Lateral/directional dynamics to meet the desired margin and flying qualities criteria
Topics Covered	**Motions of Aircraft:** Primary Definitions, 6 DOF Motion, Aerodynamic Angles, Forces and Torques, Aircraft Position and Orientation, Stability-Frame and Body-Frame, Euler's Equations (3) **Linearization of Equations of Motion:** Small Disturbance Theory and Linearization of Equations of Motion, Stability and Control Derivatives (2) **Longitudinal Dynamics:** Aircraft Longitudinal Dynamics, Longitudinal Motion Approximations, Short period mode, Phugoid mode, Influence of Stability Derivatives, Transfer Functions, Flying Qualities (5) **Lateral Dynamics:** Aircraft Lateral Dynamics, Lateral-Directional Equations, Dutch Roll, Roll and Spiral Modes, Approximate Models, Transfer Functions, Flying Qualities (5) **Stability and Control:** Static Stability Basics, Longitudinal static stability, Lateral/directional static stability, Dynamic Stability (3) **Classical Design Techniques for Flight Control:** Review of Control System Analysis/Synthesis Techniques, Closed loop performance specifications, Longitudinal Stability Augmentation System and Control Augmentation System Designs, Lateral Stability Augmentation System and Control Augmentation System Designs, Design for Aileron to Rudder interconnect gain, Concept of Autopilot design, Design of 2 Loop, 3 Loop Roll Autopilot (12) **Advanced Design Techniques for Flight Control:** Design of longitudinal and lateral Stability Augmentation System using Pole Placement, Linear Quadratic Regulator with Output feedback, Linear Quadratic Regulator with full state feedback, Designing Performance Index, Tracking a command (12)
Text Books, and/or reference material	Suggested Text Books: 1. Stevens and Lewis, Aircraft Control and Simulations, Wiley & Sons, 3rd Edn 2. Dynamics of Flight Stability and Control by Etkin and Reid, John Wiley & Sons, 3rd Edn Suggested Reference Books: 1. Flight Stability and Automatic Control by Nelson, WCB/McGraw-Hill, 2nd Edn 2. Introduction to Flight by Anderson, McGraw-Hill, 2nd Edn 3. Guided Weapon Control Systems by Garnell and East, 1st Edn Pergamon Press, 1980

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	1	2	1	3	1	1	1
CO2	2	2	3	1	2	1	2	1	2	1	1	1
CO3	3	3	3	2	2	1	2	1	3	1	1	1
CO4	3	3	2	2	1	1	2	1	3	1	1	1
CO5	3	3	3	2	2	1	3	1	2	1	1	1
CO6	2	3	3	2	3	2	3	1	3	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEO 741	**Non-conventional Energy Systems**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NA	CT+EA

Course Outcomes	CO1: Identify and explain the use of non-conventional energy systems. CO2: Develop an understanding that solutions to energy-related problems are complex involving sociological, economic, political and technological considerations, decisions and development. CO3: Gain insight into the issues surrounding non-conventional energy sources development and use. CO4: Become knowledgeable about applications of non-conventional energy systems as they apply to commercial, residential and industrial markets.
Topics Covered	Traditional energy systems, Sources, Features and characteristics, applications 2 Component of solar energy systems, Collector types and performances, Radiation and meteorological data processing, Long term conversion factors, System conversion and system design procedures, Solar power generation, Solar heating and cooling, Solar passive systems: Solar still, Pond, Greenhouse, Dryer, Trombe wall, Overhangs and Wing walls. 13 Wind energy conversion systems, Estimate of wind energy potential, Aerodynamic and mechanical aspects of wind machine design. 4 Principles and applications of wave energy, Shoreline systems, Near shore systems, Off shore systems 3 Tidal energy, Biomass energy, Operating principle, Wood gassifier, Pyrolysis, Applications, 4 Geothermal energy and OTEC. 4 Fuel cell: Types and technology status. 3 Hydel Power Plant: Introduction to hydro-electric power generation, Types of Hydel turbines, Layout and selection of turbines and installation, Geographic limitations, Turbine performance, Comparative analysis between thermal and hydel plants. 9
Text Books, and/or reference material	**Suggested Text Books:** 1) Solar Energy Fundamentals and Applications-- Garg and Prakash 2) Solar Energy-- S. P. Sukhatme **Suggested reference books:** 1) Fundamentals of Renewable Energy Systems-- D. Mukherjee and S. Chakrabarti 2) Non-conventional Energy Sources-- D. S. Chauhan and S. K. Srivastava

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMO 541	Basic Manufacturing Processes	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Engineering Physics (PH-01)	CT+MT+EA

Course Outcomes	CO1: To understand the basic fundamental of structure and properties of metal CO2: To learn fundamentals of different manufacturing process. CO3: To learn science and technological aspects of the different manufacturing techniques
Topics Covered	Introduction: Importance of manufacturing process. Economic & technological consideration in manufacturing. Classification of manufacturing processes. Materials & Manufacturing processes for common items. [4 hours] Crystallography and Equilibrium Phase Diagram: Concept of unit cell space lattice, Bravais lattices, common crystal structure, Defects and dislocation in solids. Uniary and Binary diagram, phase rules, Types of equilibrium diagrams, Solid solution type and combination type. Iron-carbon equilibrium phase diagram. [6 hours] Mechanical Properties: Materials Structure and properties of engineering materials, stress-strain diagrams for engineering materials. Stress vs Strain, toughness, Hardness, Fracture, Fatigue and Creep. Ductile & brittle materials. Heat treatment of steels Annealing, Normalising and hardening. [5 hours] Metal Forming Processes: Forming: Plastic deformation and yield criteria; fundamentals of hot and cold working processes; Load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; Work required for forging operation, Different forging operation, different forging tools. Condition for rolling force and power in rolling. Rolling mills & rolled section. Hot and cold working Rolling, forging, wire & tube drawing, deep drawing extrusion [8 hours] Manufacturing Processes: Metal casting: patterns and moulds making, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair. [5 hours] Joining: Physics of welding, Process of different welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints. [5 hours] Heat treatment: hardening, annealing, tempering, normalizing, surface hardening, case hardening. [2 hours] Powder Metallurgy: Powder Metallurgy Manufacturing Process. Principles of powder metallurgy. The need, Process, advantage and applications. [3 hours]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Rajender Singh: Introduction to Basic Manufacturing Processes & Workshop Technology, New Age International (P) Limited, Publishers, 2006. 2. Metals Handbook, Casting, vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998. <u>Suggested Reference Books:</u> 1. O. P. Khanna: Foundry technology, 17th Edition, Dhanpat Rai Publications, 2011. 2. George. E. Dieter: Mechanical Metallurgy, McGraw-Hill Co. Company.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3								1	1	3
CO2	3	3				1				1	3	3
CO3	3	3				1					3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO741	Human Resource Management	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
nil		CT+MT+EA					
Course Outcomes	• CO1: Understanding the different aspects of Human resource in an organization • CO2: Understanding the theory of motivation • CO3: Understanding the correlation of work –rewards- stress.						
Topics Covered	Studying of Characters of individuals in terms of Behavioural Pattern. [4] Framework of human resource development: influences on employee behaviour, learning and HRD, [5] Recruitment Methods and its policy. [1] Applications of human resource development: employee socialization and orientation, skills and technical training, coaching and performance management, mentoring, employee counselling and wellness services. [4] Motivation and Study of Performance appraisal methods. [3] Wage Theory And its application. [2] TQM and empowerment, stress and time management. [4] Trade unions and its role in HRM. [2] HRD, Organizational Learning, and learning organizations [4] HRM in the next century. [1]						
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1) David A. DeCenzo and Stephen P. Robbins, Human Resource Management, Prentice hall of India. 2) Werner and DeSimone (2006). Human Resource Development. Thomson Press, Network. <u>Suggested Reference Books:</u> 1) Ghosh A.K., Human Resource Management, Manas Publications, 2007. 2. Dessler G. Fundamentals of Human Resource Management Pearson Education; First edition, 2010.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

BASKET - 4

DEPARTMENT OF MANAGEMENT STUDIES							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO-841	MARKETING RESEARCH AND ANALYTICS	PEL	3	0	0	3	3
Pre-requisites- NIL		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1. Students will be aware of technique of customer segmentation and new product designing CO2. Students will be informed about understanding customer perception on competitive brands CO3. Students will be educated on technique of comparative analysis on various marketing matrix
Topics Covered	**UNIT I:** Conceptualization and process for conducting research on marketing problems **(5)** **UNIT II:** Application of univariate and multivariate techniques in solving marketing problem. Application of independent sample, before –after T, chi- square statistics to solve marketing problem; Guidelines for application of statistical software.(9) **UNIT III:** Experimental design and its application. Guidelines for application of statistical software.(4) **UNIT IV:** Application of cluster analysis for solving market – segmentation problem. Making of similarity index from categorical data .Distance and correlation based approach for building similarity index. Software based application.(9) **UNIT V:** Application of conjoint analysis in designing consumer preference. Discussion of case studies in relation to design new product /service.(7) **UNIT VI:** Application of other Multivariate techniques for solving relevant marketing problems(10)
Text Books, and/or reference material	Text Books: 1. Applied Multivariate Statistical Analysis, Richard A. Johnson, Dean W. Wichern, Person Prentice Hall **2.** Multivariate Data Analysis, Joseph F. Hair, William C. Black, Barry J. Babin, Rolph E. Aderson, Person Prentice Hall. 3. Marketing Research: An Applied orientation, Naresh K. Malhotra, Person Prentice Hall 4. Business Research Methods, Prahlad Mishra, Oxford University Press India

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO841	**Quantum Physics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To be proficient in the fundamental mathematical languages used, such as matrix algebra, in quantum information theory)2: To understand and implement basic quantum algorithms (Shor, Deutsch-Jozsa etc) CO3: To understand limitations to quantum computation introduced by quantum decoherence CO4: To be knowledgeable about advanced topics such as teleportation, Bell's inequalities and EPR paradox.						
Topics Covered	**Quantum Mechanics Introduction** [9] History of quanta, base states and superposition, structural randomness, measurement: how long is a qubit?, Heisenberg's Uncertainty Principle, waveform collapse in the macroscopic limit **Matrix Algebra** [8] Basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation **Fundamentals of Quantumness** [7] Abramsky-Coecke semantics, no-cloning theorem, quantum entanglement ('spooky action at a distance'), Bell states and Bell inequalities **Quantum Circuits** [6] Pauli, Hadamard, phase, CNOT, Toffoli gates, quantum teleportation, universality of two-qubit gates, reversible computing **Quantum Algorithms** [6] Deutsch-Josza algorithm, Simon's problem, quantum Fourier transform, Shor's period-finding algorithm, quantum key distribution (BB84, E91) **Quantum Error Correction** [3] Error correction codes **Quantum Computers** [3] Physical qubits, noise and decoherence						
Text Books, and/or reference material	**TEXT BOOKS:** 1. Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press. 2. Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press. 3. Mermin, N. David (2007). Quantum Computer Science: An Introduction. Cambridge University Press. **REFERENCE BOOKS:** 1. Yanofsky, Noson S. and Mirco A. Mannucci (2008). Quantum Computing for Computer Scientists. Cambridge University Press. 2. McMahon, David (2008). Quantum Computing Explained. John Wiley & Sons, Inc. 3. Quantum Computing for Everyone						

Mapping of CO (Course outcome) and PO (Programme Outcome)

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1	1	1	1
CO3	3	3	3	2	2	1	1	1	1	1	1	1
CO4	3	3	2	2	2	2	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO840	Industrial Biotechnology	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
Life science			CT+MT+EA				
Course Outcomes	CO1- To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results CO-2 Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes CO-3 .Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques CO-4 Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation CO-5 Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation						
Topics Covered	**UNIT 1 CELL CULTIVATION ,GROWTH KINETICS** -- 10 Hrs Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals.. **UNIT 2-MEDIA PREPARATIONand STERILIZATION** 10 Hrs Sterilization: basic concepts in sterilization in situ and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter **UNIT 3- BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs** Purpose and importance of bioreactor, Parts of fermenter and types ;Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility Operational modes of bioreactor: batch, semi-batch/fed batch,						

	continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor. **UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and A PPLICATIONS** -10Hour Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases). Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.
Text Books, and/or reference material	Suggested Text Books: 1. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011. Suggested Reference Books: 1. Ashok Pandey et al., "Enzyme Technology", Springer Publisher, 2006. 2. Nielsen et al., "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), "Downstream Processing of Proteins: Methods and Protocols", Humana Press, 2000. 4. Satinder Ahuja, "Handbook of Bioseparations", Vol 2, Academic Press, 1st Ed., 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1				-		-	
CO2	2	3	1	3	2	2	-		-		-	
CO3	1		1	2	2	2	-				-	
CO4	1	2	3	3	-	1	1					
CO5	1	2	3	3	1	2	1					

<table>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Title of the course</th><th rowspan="2">Program Core (PCR) / Electives (PEL)</th><th colspan="4">Total Number of contact hours</th><th rowspan="2">Credit</th></tr>
<tr><th>Lecture (L)</th><th>Tutorial (T)</th><th>Practical (P)</th><th>Total Hours</th></tr>
<tr><td>CEO840</td><td>Finite Element Analysis and Applications</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite(s)</td><td colspan="6">Course Assessment methods</td></tr>
<tr><td colspan="2">Mechanics, Mathematics, Engineering problems in various fields</td><td colspan="6">Continuous (CT) and end assessment (EA). CT+EA</td></tr>
<tr><td>Course Outcomes (COs) :</td><td colspan="7">· CO1: Knowledge of importance of FEA over classical methods and use it for modelling and analysis of real life engineering systems.
· CO2: Learning to simulate physical systems related to various engineering fields through FE modelling & interpret analysis data for prediction of system response.
· CO3: Skill to use computational tools for solving engineering problems.
· CO4: Foundation for using advanced FEA software packages for modelling and analysis of problems related to relevant field of studies in both industry and research.</td></tr>
<tr><td>Topics Covered (Hrs)</td><td colspan="7">Introduction: Recapitulation of Matrix Manipulation Techniques, Solution of Simultaneous Linear Equations, Inverse of Matrix, Eigen Values and Eigen Vectors, Computer Implementation. (5)
Engineering Problems: Different numerical methods, History of Finite Element Method (FEM), Steps in FEM, Areas of Application, Verification problems, implementation of Engineering Problems in FEA. (10)
Spring Element: General, Implementation in FEA, Applications, Problems. (5)
Bar Elements: Definition, Property Matrix using Direct and Energy Approach, Engineering Implementation in FEA, Problems and Validation. (6)
Application of FEA: General Conduction Problems, Mechanical systems, Electrical systems etc. Validation, convergence study and error analysis in solution of real life engineering problems. (10)
Computer Programs/ SOFTWARES in FEA. (6)</td></tr>
<tr><td>Text Books, and/or reference material(s)</td><td colspan="7">Text Books:
1. Finite element analysis: theory and programming by C S Krishnamurthy (2001). Publisher: Tata McGraw Hill Education
2. Finite Element Analysis Theory and Application with ANSYS by Moaveni. Publisher: Pearson (2008)
3. Fundamentals of Finite Element Analysis by David V. Hutton. Publisher: Tata Mcgraw Hill Education Private Limited (2005)
Reference Books:
4. Finite Element Procedures by Klaus-Jurgen Bathe. Publisher: Prentice-Hall (2009)</td></tr>
</table>

Mapping of Course Outcomes COs → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	2	-	-	-	-	-	-	-	-
CO3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	-	2	-	3	-	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO841	**Disaster Management and Mitigation**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
None		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes (COs):	· CO1: Understanding Disaster · CO2: Ability to manage disaster · CO3: Use of Modern tools to manage disaster
Topics Covered (Hrs)	**Understanding Disasters:** Understanding the Concepts & definitions of Disaster, Hazard, Vulnerability, Risk, Capacity–Disaster, Development & management **(5)** **Types, Trends, Causes, Consequences and Control of Disasters:** Geological Disasters (earthquakes, landslides, tsunami, mining); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire); Technological Disasters (chemical, industrial, radiological, nuclear) and Manmade Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters) Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters **(10)** **Disaster Management Cycle and Framework:** Disaster Management Cycle – Paradigm Shift in Disaster Management Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief and Rehabilitation – Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment **(10)** **Disaster Management in India:** Disaster Profile of India – Mega Disasters of India and Lessons Learnt Disaster Management Act 2005 – Institutional and Financial Mechanism National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter Governmental Agencies **(5)**

	Applications of Science and Technology for Disaster Management: Geo-informatics in Disaster Management (RS, GIS, GPS and RS) Disaster Communication System **(5)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Disaster Management by W. Nick. Carter, 1991: Asian Development Bank, Manila 2. Introduction to International Disaster Management by D. P. Coppola, 2007, Elsevier Science (B/H), London. 3. Manual on natural disaster management in India by M C Gupta, NIDM, New Delhi ***Reference Books:*** 4. An overview on natural & man-made disasters and their reduction by R K Bhandani, CSIR, New Delhi 5. http://www.nidmindia.nic.in/

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	3	-	2	-	-	-	-
CO2	1	-	-	-	-	3	-	2	-	-	3	-
CO3	1	-	-	-	3	-	-	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO842	**Experimental methods in Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Basic Engineering, statistics & probability	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs):	· CO1: Development of skills for predicting engineering system behaviour · CO2: Knowledge of basics of data analysis for further applications. · CO3: Developing the requisite skill that helps in the advanced courses related to experimental study
Topics Covered (Hrs)	**Types of measurements and errors**: Internal & external estimates of errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Best estimate of true value & precision, Methods of calculating best estimate of true value & standard deviation **(7)** **Combination of measurements**: Accuracy of mean, Significant digits. Method of least squares & its application for calculation of best estimate of true value, curve fitting, **(8)** **General linear regression**: Comparison & combination of measurements. Extensions of least square method. Theory of errors, Binomial & Gaussian distribution, Confidence limits, Significance test, principle of maximum likelihood & goodness of fit, Chi-square test. **(9)**

	Displacement measurement: Dial Gauge, Microcator, Optical Method, Pneumatic Transducer, Strain Gauges, Variable Inductance & Capacitance Transducer, Piezo-Electric, Electro-Kinetic, Photo-Electric, Ionization, Vibrating Wire & Vacuum Tube Transducer. **Force & Torque:** Elastic Type, Fluid Load Cell, Dynamometers. **Temperature:** Bi-Materials, Pressure & Resistance Thermometers, Thermocouples & Pyrometers. **Pressure:** McLeod Gauge, Pirani Gauge, Ionization Gauge, Manometers, Bourdon Tube, Resistance Gauges. **Fluid Velocity:** Pitot tube & Hot Wire Anemometer, LDA. Flow Measurement in Confined Passages & Open Channels. Miscellaneous measurements **(10)** **Dynamic Response** of a Measuring Instrument, Response to Transient & Periodic Signals, First & Second-order systems as well as their Dynamic Response Characteristics. (**8)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Instrumentation, Measurement and Analysis by B C Nakra and K K Chaudhary, Tata McGraw Hill, 1985. 2. Principles of Measurement, Precision, Error and Truth by N C Barford, Addison Wesley, 1967. ***Reference Books:*** 3. Physical Measurement and Analysis by N N Cook and E Rabinowicz, Addison Wesley, 1963 4. Experimental Methods for Engineers by J P Holman and W J Gajda, McGraw Hill Co., 1978

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	-	-	1	2	-	2
CO3	-	-	3	-	-	-	-	2	-	2	1	3

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO841	**BIO-ENGINEERING AND INDUSTRIAL APPLICATION**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MAC01, CYC01		CT+MT+EA					
Course Outcomes	• CO1: Understand the kinetics of different bioprocess for the design of bioreactor. • CO2: Analyze the performance of bioreactors. • CO3: Apply the knowledge of bioprocess for industrial production.						
Topics Covered	**Module I:** [15 hrs.] Introduction of Bioprocesses and their important in process industry; Free enzyme kinetics; Inhibition in enzymatic reactions. Bioreactors for enzymatic reactions.						

	Module II: [15 hrs.] Cell growth kinetics; Growth models, Inhibition in cell growth kinetics, Reactors for cell growth system. Combination of bioreactors for cell growth. **Module III:** [10 hrs.] Downstream processing in bioprocesses; Intra and extracellular product extraction and separation. Industrial application of bioprocesses. **Module IV:** [10 hrs.] Application of enzymatic reactions in industrial production. Production of HFCS. Application of cell growth reactions in industrial production. Biofuel production, waste water treatment.
Text Books, and/or reference material	Suggested Text Books: 1. J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, Second Edition, Mc. Graw Hill Inc., Singapore, 1986. 2. H. W. Blanch, D. S. Clark, Biochemical Engineering, Special Indian Edition, Marcel Dekker Inc. New York, 2007. 3. M. L. Shuler, F. Kargi, Bioprocess Engineering - Basic Concepts, Second Edition, Prentice Hall of India Private Ltd., New Delhi, 2002. Suggested Reference Books: 1. P. M. Doran, Bioprocess Engineering Principles, Academic Press, California, 2009. 2. J. Nielsen, J. Villadsen, G. Liden, Bioreaction Engineering, Second Edition, Springer, 2007. 3. D. G. Rao, Introduction to Biochemical Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	1	1	2	2	2	3	1
CO2	3	2	3	2	3	1	1	2	2	2	3	1
CO3	3	2	3	2	3	1	1	2	2	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO842	**ENERGY INTEGRATION AND ECONOMICS IN PROCESS INDUSTRY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Heat Transfer		CT+MT+EA					
Course Outcomes	• CO1: To identify and understand the method of data extraction for energy integration in the process industry • CO2: To analyse the process heat data to minimize energy cost. • CO3: To create the low cost heat integrated process.						
Topics Covered	**Module I:** [8 hrs.] Introduction to process Integration (PI) and Pinch Technology. **Concept** of ΔT_{min}, Data Extraction, Composite curve, Grand Composite Curve, Targeting, Graphical representations. Rules of data extraction. Problem Table Algorithm.						

	Module II: [8 hrs.] Introduction to Energy Targeting, principle of pinch, problem table algorithm, Grand composite curve analysis, Threshold problems, Multiple utility targeting with grand composite curve. Number of units targeting. **Module III:** [8 hrs.] Introduction to area targeting, balanced composite curves, area targeting for unequal heat transfer coefficient, area targeting for equal heat transfer coefficient, shell targeting. **Module IV:** [8 hrs.] Introduction to cost targeting, capital cost targeting, operating cost targeting, total cost targeting, cost targeting for optimum ΔT_{min}. **Module V:** [10 hrs.] Pinch design method for heat exchanger network (HEN) synthesis, rules of pinch design method, remaining problem analysis, design for multiple pinch problem. HEN optimization with case studies.
Text Books, and/or reference material	Suggested Text Books: 1. Ian C. Kemp, Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy, 2nd Edition, ISBN: 9780750682602, Butterworth-Heinemann, 2016. 2. Shenoy U. V.; "Heat Exchanger Network Synthesis", Gulf Publishing Co. 3. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. Of Chemical Engineers. Suggested Reference Book: 1. Smith R.; "Chemical Process Design", McGraw-Hill.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

Pos / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	-	-	-	-	-	-
CO2	3	3	3	3	3	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO841	CAD for VLSI	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Digital Electronics, Computer Organisation, Algorithm Analysis and Design.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: To visit the various stages of the VLSI design cycle and appreciate the role of automation therein. • CO2: To appreciate how High Level Synthesis converts an HDL code into an architecture level design. • CO3: To discuss the algorithmic approach to physical design. • CO4: To emphasize the importance to testability measures in the design.						

Topics Covered	VLSI Design cycle. Design styles. System packaging styles. Fabrication of VLSI devices. Design rules-overview. (3L) HLS: Scheduling in High Level Synthesis. ASAP and ALAP schedules. Time constrained and Resource constrained scheduling. (4L) HLS: Allocation and Binding. Datapath Architectures and Allocation tasks. (4L) Partitioning. Clustering techniques. Group Migration algorithms. (4L) Floorplanning. Constraint based Floorplanning. Rectangular Dualization. Hierarchical Tree based methods. Simulated Evolution approaches. Timing Driven floorplanning. (5L) Placement.Simulation based placement algorithms. Partitioning based placement algorithms.ClusterGrowth.(5L) Global Routing. Maze Routing algorithms. Line probe algorithms. Shortest Path based algorithms. Steiner's Tree based algorithms. (5L) Detailed Routing. Channel Routing Algorithms. Switchbox Routing. Over-the-cell routing. Clock and Power Routing. (4L) Design for testability. Fault testing. Ad-hoc and structured DFT techniques.(8L)
Text Books, and/or reference material	**Text Books:** 1. Algorithms for VLSI Physical Design Automation. N.A.Sherwani. Kluwer Academic Publishers. 2. High-Level Synthesis: Introduction to Chip and System Design. Gajski et. al. . Kluwer Academic Publishers. 3. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications. **Reference Books** 1. VLSI Physical Design Automation. Sadiq M. Sait and Habib Youssef. Kluwer Academic Publishers. 2. Algorithms for VLSI Design Automation. Sabih H. Gerez. Wiley India. 3. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12
CO1	3	2	2	3	3	2	1	-	-	-	2	-
CO2	3	3	3	3	3	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-
CO4	3	3	3	3	2	-	2	-	-	-	1	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Cred it
			Lectur e (L)	Tutori al (T)	Practical (P)	Total Hour s	
CSO 842	Internet and Web Technologies	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Programming Fundamentals, Data Structure and Algorithms, Operating Systems, Data networks (may be carried out		CT+EA [CA: 15%, MT: 25%, ET: 60%]					

simultaneously)	
Course Outcomes	• CO1: Understanding the fundamental concepts of Internet Structure and Protocols. • CO2: Using TCP/IP protocols, SOCKET API and HTTP. • CO4: Designing and developing Web applications with security enhancement. • CO5: Understanding Semantic Web and Applying Web Analytics over Semantic Web.
Topics Covered	INTERNET TECHNOLOGY: Brief review of Data Networking; Introduction to Data Communication, OSI Layered Architecture, Introduction to Networking Devices, Network Performance Metrics. (4L) data transmission over point to point links, link sharing and MACs, Forwarding and Routing, TCP-IP layered network concepts. (3L) Internet specific issues like scalability, inter operability. (1L) Internet Structures – logical and physical grouping with sub netting and super netting. (3L) Review of TCP-IP protocols – processing, performance and variations. (3L) Security Implementations - secured IP, Transport Layer security. (3L) Quality of Service Issues and their Application in Internet. (2L) HTTP: Requests and Responses - Message Formats, Headers and Fields; TCP Keep-alive and pipe-lining concepts; Server Architecture, Performance and Deployment. (3L) WEB PROGRAMMING: Document Object Model; Client side scripting fundamentals: Server Side Scripting and Programming – Data base connectivity, session management and security enhancement; Introduction to Web Application Development Platforms – JavaEE, Dzango. (7L) XML: DTD and Schema; Visualisation using XSLT; Web Application using XML; Service Oriented Architecture and Web services based application development and deployment; Xquery and SOA based application development platforms. (6L) SEMANTIC WEB: General Concept of Semantic Web and linked Data; RDF based relation description; Web Ontology concepts and use; Putting XML, RDF and Ontology together to develop semantic web applications; Capturing Information from semantic web pages; Data analytics over semantic and linked Web. (7L)
Text Books, and/or reference material	**Text Books:** 1. B. A. Forouzan, "TCP/IP Protocol Suite", 4th Edition, 2010, McGrawHIll. 2. P. Deitel, H. Deitel, A Deitel, "Internet and World Wide Web – How to Program", Pearson. 3. G. Antoniou, P. Groth, F. Harmelen and R. Hoekstra, "A Semantic Web Primer" Prentice Hall India. **Reference Books:** 1. D. E. Comer & D L Stevens, "Internetworking with TCP/IP vol.II", Pearson. 2. www.w3schools.com

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	1	1	-	1	-	-	-	2
CO2	2	1	2	-	2	2	1	1	1	-	1	2
CO3	2	2	2	2	3	3	2	3	3	3	1	1
CO4	2	3	2	3	3	3	1	3	3	3	-	-

Correlation levels 1, 2 or 3 as defined below:

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO843</td><td>Soft Computing Techniques</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Introduction to computing, Data Structures and Analysis of Algorithms</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
CO1: Understand the fundamental concepts, different architectures and learning algorithms for neural networks and its limitations.
CO2: To introduce evolutionary computing and understanding single and multi-objective genetic algorithms and their applications in optimization problems.
CO3: To introduce the fuzzy sets, fuzzy logic and fuzzy inference system.
CO4: To introduce tools and techniques of Soft Computing.
CO5: To apply soft computing techniques to solve application problems.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Introduction (6L)
Introduction and different definitions of Soft Computing with their application in real life problems, Basic tools/members of Soft Computing: Fuzzy Logic, Neural Network and Evolutionary Computing.
Module II: Fuzzy Logic (12L)
Fuzzy Logic-I: Crisp Sets, Fuzzy sets, Fuzzy membership functions, Basic operations on fuzzy sets, Fuzzy relations and Composition of fuzzy relations.
Fuzzy Logic –II (Fuzzy Rules and Approximate Reasoning): Fuzzy if-then rules: M-A and TSK Rules, Fuzzification, Compositional rule of Inference/Approximate Reasoning, Defuzzification and Applications.
Module III: Neural Networks (10L)
Neural Networks-1 (Introduction & Architecture): Introduction to neural networks: Artificial Neuron and its model, Activation functions, Neural network architecture, learning algorithms/rules, Training and testing.
Neural Networks-II: Perceptron model: single layer and multilayer perceptron (MLP), Error back propagation, Radial basis function network (RBFN), Self-organizing map network (SOMN).
Module IV: Evolutionary Computing (14L)
Evolutionary Computing-I: Evolutionary Computing, Basic concepts and working principle of simple GA (SGA), Genetic Operators: Selection, Crossover and Mutation, flow chart of SGA, Chromosome Encoding & Decoding, Population Initialization, Objective/fitness Function, variable length Chromosome, Introduction to Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Local Search and Memetic algorithm, Application to Travelling Salesman Problem (TSP).
Evolutionary Computing-II: Multi-objective Genetic Algorithm (MOGA)): Conflicting objectives, Objective space and variable space, Domination, Pareto front, Pareto Set, NSGA-II: Non-domination Sorting, Crowding distance operator, Applications.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
S. Rajsekharanand and Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications”, Prentice Hall of India.</td></tr>
</table>

	2. N. P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press. 3. G. Klir and B. Yuan, "Fuzzy sets and Fuzzy logic", Prentice Hall of India. 4. K. H. Lee., "First Course on Fuzzy Theory and Applications", Springer-Verlag. 5. G. J. Klir and T. A. Folger: Fuzzy Sets, Uncertainty, and Information, PH. 6. J. Yen and R. Langari, "Fuzzy Logic, Intelligence, Control and Information", Pearson Education. 7. D. Goldberg: Introduction to Genetic Algorithm. **Reference Books:** 1. Siman Haykin, "Neural Networks", Prentice Hall of India. 2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley India. 3. Kumar Satish, "Neural Networks", Tata Mc. Graw Hill. 4. B. Yegnanarayana , "Artificial Neural Networks" 5. A. Konar, "Computational Intelligence", Springer. 6. Y. H. Pao: Adaptive Pattern Recognition and Neural Networks, Addison-Wesley.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	2	3	3	3	3	-	-	-	-	-	-	3
CO2	2	3	3	3	3	-	-	-	-	-	-	3
CO3	2	3	3	3	3	-	-	-	-	-	-	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3
CO5	3	3	3	3	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO844</td><td>Compiler Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">CSC-01 (Introduction to Computing)</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the fundamental idea of compiler.
• CO2: Implement a part of a compiler.
• CO3: Know how a compiler recovers from an error.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Introduction to Regular Expressions, NFA and DFA. 3L
• Introduction to the philosophy of compilers and course Overview. Introducing different phases of compilers with an example. 1L
• Details of Lexical analysis phase. Implementation of a Lexical analyzer. 4L
• Regular expression versus Grammars. Different types of Top-Down parsing. Different types of Bottom -up parsing. Implementing one Bottom -up parsing algorithm. 12L
• Introduction to Error Recovery Routine, Type Checking and</td></tr>
</table>

	Symbol Table. Introduction to lex and yacc. 4L • Syntax Directed Translation scheme. 6L • Intermediate code generation. Three Address Codes. 5L • Code generation and code optimization. 5L • Linker, Loader 2L
Text Books, and/or reference material	**Text Books:** Compilers: Principles, Techniques, and Tools (Latest Edition). Alfred Aho, Monica Lam, Ravi Sethi, and Jeffrey Ullman. Addison-Wesley **Reference Books:** Engineering a Compiler. Keith Cooper and Linda Torczon. Morgan Kaufman

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	-	-	2
CO2	2	2	3	3	3	-	-	-	1	1	3	2
CO3	2	2	2	2	2	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO840	Structronics	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))
Basic Electronics (ECC01), Engineering Mechanics (XEC01)	Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination
Course Outcomes	After the completion of the course the student will be able to • **CO 1:** Understand concept of Smart Materials based Electronic Devices • **CO 2:** Apply quantitative analysis techniques to Smart Materials based Electronic Devices • **CO 3:** Understand basic building blocks of Smart Materials based Electronic systems • **CO 4:** Learn design techniques of Smart Materials based Electronic systems • **CO 5:** Investigate application specific Smart Materials based Electronic systems
Topics Covered	**Module I: Introduction to Smart Materials based Electronic Devices [L-1]** Smart Materials, Smart Materials based Electronic Devices, Applications of Smart Materials based Electronic Devices **Module 2: Characteristics of Smart Materials based Electronic Devices [L-9]** Static, dynamic and quasi static characteristics **of** Smart Materials based Electronic Devices **Module 3: Analysis and Modelling of Smart Materials based Electronic Devices [L-12]** Energy, Co-energy, Energy methods, Hamilton’s principle, Lagrange's Equations, Analysis and modelling of Smart material based electromechanical devices **Module 4: Piezoelectric Devices [L-8]** Piezoelectric sensors, actuators, transformers, motors, resonators

	Module 5: Shape Memory Alloy devices [L-4] Shape Memory effect , Shape Memory Alloy elements, Shape Memory Alloy elements as actuators, Shape Memory Alloy element as sensor **Module 6: Electroactive polymer devices [L-3]** Electroactive polymers, Electroactive polymer actuators **Module 8: Case studies [L-5]** Piezoelectric transducers for ultrasound generation, SMA actuator driven finger exoskeleton
Text Books, and/or reference material	**Text Books:** 1. V. K.Varadan, K.J.Vinoy, S.Gopalakrishnan , *Smart Material Systems and MEMS: Design and Development Methodologies*, Wiley, 2006 2. J. Bentley, *Principles of measurement systems*. Pearson Education India; 3rd edition, 2002 3. S. H. Crandall, D. C. Karnopp, *Dynamics of Mechanical and Electromechanical*, Medtech Pub, 2017 **Reference books:** 1. D. J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & Sons Inc, 2007 2. A. Preumont *Mechatronics, Dynamics of Electromechanical and Piezoelectric Systems*, Springer, 2011 3. D. K. Gehmlich, S. B. Hammond, *Electromechanical system*, McGraw-Hill, 1967 4. D. Hutton, *Fundamentals of Finite Element Analysis*, McGraw Hill, 2003 5. Research articles

COURSE ARTICULATION MATRIX

PO/PSO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	-	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	3	2	-	1	-	-	-	-	-	-	-	-
CO#4	3	2	-	1	-	-	-	-	-	-	-	-
CO#5	1	1	-	3	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO841	Signal Processing	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), Mid-Term (MT), End Assessment (EA))					
Signals and Systems (ECC303), Mathematics-II & III (MAC02 & MAC331)		Class Assignments, Mid and End term examinations					
Course Outcomes	**CO#1**. Represent signals in time and frequency domain. **CO#2**. Implement DFT, FFT and z-transform. **CO#3**. Analyse a given signal or system using tools such as Fourier						

	transform and z-transform to know the property of a signal or system. **CO#4**. Design of prototype of Linear Phase Filters, FIR and IIR Filter Structure. **CO#5**. Process signals to make them more useful and to design a signal processor (Digital filter structures) for a given problem.
Topics Covered/ Syllabus	Introduction: reasons behind digital processing of signals, brief historical development, organization of the course. (L=2) Theory of discrete time linear system sequences, linear time invariant systems, causality, stability, difference equations, frequency response, discrete Fourier series, relation between continuous and discrete systems, Inverse Systems, Stability. (L=2) Z –transform: definition, properties of Z transform, system function, digital filter implementation from the system function, region of convergence in the Z plane, determining filter coefficients from the singularity locations, geometric evolution of Z transform in the Z plane, relationship between Fourier transform and Z transform, inverse Z transform. (L=4) Transform technique: Fourier transform, its properties, inverse Fourier transform, discrete Fourier transform, properties of DFT, circular convolution, computations for evaluating the DFT, decimation in time and decimation in frequency FFT algorithms, discrete Hilbert transform. (L=5) Digital filter structures: system describing equations, filter categories, All Pass Filters, Comb Filters, direct form I and II structures, cascade and parallel communication of second order systems, Polyphase representation of filters, linear phase FIR filter structures, Compensatory Transfer Functions, frequency sampling structure for the FIR filter. Test for Stability using All Pass Functions. (L=6) IIR filter design techniques: Analog Filter Design, Analog Butterworth lowpass filter design techniques, Analog Chebyshev LPF, Design methods to convert analog filters into digital filters, frequency transformation for converting lowpass filters into other types, all-pass filters for phase response compensation. (L=6) Digital Filter Structures: IIR Realizations, All Pass Realizations, FIR and IIR Lattice Synthesis, IIR Design by Bilinear Transformation, Digital to Digital Frequency Transformation. (L=6) FIR filter design techniques: Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filter, frequency sampling method for designing FIR filter (L=6) Non-Linear System Identification Schemes, Fractional-order digital differentiators (DDs) and digital integrators (DIs), Fractional-order low-pass Butterworth and Chebyshev filter. (L=5)
Text Books, and/or Reference material	**Text Books**: 1) Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India 2) Digital Signal Processing: Principles, Algorithms and Applications (3rd Edition), John G. Proakis, Dimitris G. Manolakis, and D Sharma, Pearson Education India 3) Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 1996. ISBN:0201634678. 4) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937

	Reference Books: 1) S. W. Smith, The Scientist and Engineer's and Guide to Digital Signal Processing, California Technical Publishing, 1997. ISBN: 0-9660176-3. 2) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	2	2	1	1	1	1	1	1	1	2
CO#2	3	3	2	2	2	-	1	-	-	1	-	3
CO#3	3	3	2	3	2	1	-	-	1	-	-	3
CO#4	3	3	3	3	2	-	-	1	-	-	-	3
CO#5	3	2	3	3	2	1	1	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO842	Introduction to VLSI	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic Electronics (ECC01), Physics of Semiconductor Devices (PHC331)		CT+MT+EA					
Course Outcomes	• CO1: Outline basic knowledge of semiconductor materials, devices and growth process of Si devices • CO2: Identify the process flow of device fabrication. • CO3: Illustrate each process method of VLSI technology • CO4: Build the knowledge of integrated process technology						
Topics Covered	**Module 1: Introduction** [3L] Materials, Definitions, Scaling laws, Idea of Clean room, Si Substrate Growth and Cleaning of Si **Module 2: Oxidation** [5L] Oxidation: Process of Oxidation, Types of Oxidation, Deal-Grove Model, Dependence of oxidation on different parameters, Applications in IC technology, LOCOS. **Module 3: Lithography** [6L] Process flow of lithography, Components of Lithography, Aligner; Contact, Proximity, Projection, Metrics of Lithography, Photo resist-Positive and Negative, Mask, Next generation lithography. **Module 4: Diffusion and Ion Implantation** [7L] Basic Concepts, Diffusion in Si, Poly Si, Basic Process: Pre-deposition and Drive-in Diffusion, Problems in Thermal Diffusion, Advantages of Ion Implantation, Ion Implantation system, Mechanism, Implantation Profile, Junction Depth, Dose and Concentration relationship, Ion Implantation damage and annealing, Ion Channeling, Multi Implantation.						

	Module 5: Thin Film Deposition [6L] Requirements of deposition, Methods: Physical Vapor Deposition and Chemical Vapor deposition, Step Coverage and Filling Issues. **Module 6 Etching:** [3L] Etch process, Requirements, Figure of merits, Types of Etch, Dry and Plasma Etch, Ion enhanced Etch. **Module 7: Metallization and Interconnect** [6L] Interconnect, Interconnect requirements, Possible Interconnect materials, Al metallization, Al spike problem, Hillocks and Voids, Electromigration Problems, Methods to reduce the problems, Metal silicides, Multilevel Metallization, W plugs for contact and vias, Intermetal Dilectrics. **Module 8: IC process Integration** [6L] Simple Resistor, Capacitor, NMOS.
Text Books, and/or reference material	1. VLSI Technology: S M Sze 2. Silicon Process Technology: S K Gandhi 3. Silicon VLSI Technology: Plummer, Deal and Griffin 4. Fundamental of Semiconductor Fabrication: Sze and May

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO# 10	PO# 11	PO# 12
CO#1	1	1	1	1	-	-	-	-	-	-	-	1
CO#2	1	2	1	1	1	-	-	-	-	-	1	1
CO#3	2	3	2	2	-	1	-	-	-	-	1	2
CO#4	3	1	3	-	-	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total number of contact hours = 46				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO843	EMI/EMC	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):					
Signals and Systems (ECC303) Analog Communication (ECC401) Digital Communication (ECC501) Electromagnetic Theory and Transmission Lines (ECC403) Microwave Engineering (ECC502)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	**CO#1** Ability to understand the basic knowledge of the sources of electromagnetic interference and electronic equipment classes based on						

	standards **CO#2** Ability to analyze, explain and resolve technical problems related to electromagnetic interference **CO#3** Develop an ability to devise methodologies to mitigate electromagnetic interference and make the electronic system compatible
Topics Covered/ Syllabus	**Introduction to EMI** : Definitions, Different Sources of EMI (Electro-magnetic Interference), Electro-static discharge (ESD), Electro-magnetic pulse (EMP), Lightning, and Mechanism of transferring Electro-magnetic Energy: Radiated emission, radiated susceptibility, conducted emission, and conducted susceptibility, Differential & common mode currents. Concepts of EMC, EMC units. **[L-8]** **Transmission Line Theory** : transmission by guided media, idea of propagation characteristics and computation of VSR, reflection coefficient, scattering parameters. Transients of transmission line, Time-domain Reflectrometry (TDR) basics for determining the properties of a transmission line. Planar Transmission lines Pattern of EM field distribution in a Micro-strip Line, Derivation of Effective Dielectric Constant, Characteristic impedance & Attenuation, Different Micro-strip line design examples, coupled transmission lines, concept of signal integrity **[L-8]** **Impedance Matching & Tuning** : Purpose of Impedance matching, Factors important in the selection of a particular matching network, Different types of Impedance matching, Single stub matching, double stub matching, The quarter-wave transformer, Quarter-wave transformer bandwidth calculation, theory of small reflection, Single-section Transformer, Multi-section Transformer **[L-8]** **Electromagnetic Sensors and Measurement** : Antenna types and their use as sensors, effective height, antenna factor, broadband and multiband electromagnetic sensors, sub wavelength electromagnetic sensors, Power losses in cable, calculation of signal source output for a mismatched load, Measuring & Test systems, Test facilities, measurements of radiated emission in open test range & in Anechoic chamber, Conducted emission testing by Line Impedance Stabilization network (LISN). **[L-8]** **EMC requirements for electronic systems** : World regulatory bodies- FCC, CISPR etc. Class-A devices, class-B devices, Regulations of the bodies on EMC issues. **[L-6]** **Mitigation Techniques Grounding** : Fundamental grounding concepts, Floating ground, Single-point & Multi-point ground, advantages & disadvantages of different grounding processes. Shielding, Cross-talks & Coupling, Measurement set for measuring Cross-talk. Filtering & decoupling. **[L-6]** Electromagnetic pulse and application in warfare, electromagnetic discharge **[L-2]**
Text Books, and/or Reference material	**Text Books:** [1] Clayton R.Paul , *Introduction to Electromagnetic compatibility-* John Wiley & Sons [2] Albert A. Smith Jr., *Radio Frequency Principles and Applications: The Generation, Propagation, and Reception of Signals and Noise*, Wiley-IEEE Press, New York 1998 **Reference Books:** [1] Frederick M Tesche, Michel V.Ianoz, Torbjorn Karlsson*, EMC Analysis Methods & Computational Models-*; John Willey & Sons, Inc [2] Paul G. Huray, *The Foundations of Signal Integrity*, John Wiley & Sons, Inc., 2010

COURSE ARTICULATION MATRIX

PO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**
CO#1	2	1	2	1	2	2	1	1	1	1	1	1
CO#2	2	3	2	2	2	2	1	2	1	2	1	1
CO#3	3	3	3	1	1	2	1	1	2	2	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO840	Microgrid systems	PEL	3	0	0	3	3
Pre-requisites:		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• **CO1:** Acquire an idea about microgrid and its operations. • **CO2:** To learn the different components of the microgrid systems. • **CO2:** To study different types of microgrid and different control strategies. • **CO3:** To model and calculate different parameters of the renewable sources and the energy storage system of microgrid. • **CO4:** To learn different active and reactive power control strategies of microgrid. • **CO5:** To understand the future applications of microgrid and its role in the electrical ecosystem.						
Topics Covered	1. **Introduction:** What is microgrid, advantage of microgrid over traditional systems, architecture of microgrid, operating modes of microgrid. **(2L).** 2. **Components of microgrid:** Local generation, different loads, storage system, converters, filters, monitoring and control system **(4L).** 3. **Classification of microgrid:** AC, DC, and hybrid microgrid, architecture and components of different microgrids, classification based on control strategies, centralized and decentralized control **(5L).** **4. Renewable sources:** PV source, modelling of PV source, MPPT of PV source, different components of wind turbine, MPPT control of wind turbine, effect of uncertainty on PV and wind power **(6L).** 5. **Energy storage system:** Advantage of ESS, different type, integration of ESS, importance of storage system in microgrid **(4L).** 6. **Microgrid power control:** ABC/DQ, DQ/ABC transformation, centralized P-Q control, droop control, master-slave control, peer to peer control **(6L).** 7. **Role of microgrid in future electricity ecosystem:** Decarbonisation, digitalization, decentralization, load forecasting, load shedding, energy management. **(7L).**						
Text Books, and/or Reference Material	**Text Book:** HANDBOOK ON MICROGRIDS FOR POWER QUALITY AND CONNECTIVITY– Asian Development Bank **Reference Book:** Microgrid Technologies– C.Sharmeela, P.Shivaraman, P.Sanjeevikumar (Wiley)						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	2	1	1	1	1	1	1	1
CO2	2	3	3	3	3	1	2	1	2	0	2	1
CO3	2	3	3	3	3	0	2	1	2	0	2	0
CO4	2	3	3	3	3	2	1	1	2	0	2	2
CO5	2	2	2	2	2	1	1	3	2	0	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO841	BIOMEDICAL INSTRUMENTATION!	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO 1: Familiarization with biomedical equipment's and transducers • CO2: Introduction to biomedical signal conditioners • CO3: Acquiring knowledge about development of bio potentials and their measurements. • CO4: Introduction patient health care monitoring • CO5: Introduction to computerized imaging techniques						
Topics Covered	Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits. (8) Various types of signal conditioners, signal conditioning processes. (8) Generation of Nernst Potential, Establishment of diffusion potential, Goldmann Equation, Measurement of membrane potential, resting potential, action potential. (6) Use of electrodes for measurement of bio potentials, polarization in electrodes, principle of operation of Ag/AgCl electrode, Equivalent circuit of electrode. (6) Measurement of ECG, Einthoven triangle method, unipolar and bipolar limb leads, ECG amplifiers, Problems encountered in ECG recording. (6) Introduction to medical imaging, Radiography, Computerized tomography, X Ray, -CT, MRI. (8)						
Text Books, and/or reference material	Text Books: 1. John Enderle. Joseph Brinzino, Introduction to Biomedical Engineering, Elsevier, 2012. 2. John G Webster, Medical Instrumentation, Application & Design, John Wiley & Sons, 2009 Reference Books: 1. L. Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation & Measurements, PHI, 2014 2. Arthur C Guyton, John E Hall, Textbook of Medical Physiology, Elsevier, 2006:						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	1	3	1	1	2
CO2	3	3	3	3	3	3	1	1	3	1	1	2
CO3	3	3	3	3	3	3	1	1	3	1	1	2
CO4	3	3	3	3	3	3	1	1	3	1	1	2
CO5	3	3	3	3	3	3	1	1	3	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO842</td><td>RENEWABLE ENERGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01 (ELECTRICAL TECHNOLOGY)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the basics of Energy System and overall energy resources
• CO2: To design the solar and wind power plant
• CO3: To understand the tidal, geothermal energy, biomass and other resources and principles
• CO4: To understand the energy conservation opportunities and energy saving</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, classification relative merits and demerits, Carbon emission, carbon credit, Paris environmental meet for awareness of emission. (9)
Solar photovoltaic: Introduction, solar radiation & its relationship with photovoltaic effect. Photovoltaic concentration, photovoltaic systems-standalone, Solar Constants, Definition of solar thermal: Thermal characteristics of solar radiation, solar collectors: -materials, types, focusing. Solar thermal power plant: layout and arrangement, solar cooling, recent developments. (8)
Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. (6)
Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. (4)
Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects. (5)
Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell</td></tr>
</table>

	power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid. (5) Energy conservation opportunities, Type of energy audit, energy audit report. Saving of energy with energy economics. (5)
Text Books, and/or reference material	Text Books: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003. 2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. 3. Fuel Cell Handbook, Parsons Inc. 4. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**2**	**1**		**1**	**1**	**1**			**1**	**1**
CO2	**3**	**3**	**2**	**1**	**1**	**1**	**1**				**1**	**1**
CO3	**2**	**3**	**3**	**2**	**1**	**1**	**1**	**1**	**1**		**1**	**1**
CO4	**2**	**3**	**3**	**2**		**1**	**1**	**1**	**1**		**2**	**1**

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO843	DIGITAL IMAGE PROCESSING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	• CO1: Good understanding of several image enhancement techniques and their application to solve real life problem • CO2: Sufficient expertise in both theory and application of several image processing tasks such as image restoration, image compression, and image segmentation. • CO3: Expertise of several techniques for analysis of images • CO4: Develop basic problem-solving skills as they apply to different situations as an
Topics Covered	Introduction: Image digitization, Pixel relationship, Distance transformation, Image transformation viz. 2-D DFT, 2-D discrete cosine transform (DCT) (8) Image Enhancement: Point and algebraic operations, edge detection and sharpening, Filtering in the spatial domain, Histogram equalization, Histogram specification, sharpening filters and gradient operators, Introduction to frequency domain filtering using Fourier Transform; Basics of 2D Fourier Transform, Butterworth and Gaussian filters. (10) Image Restoration: Degradation models, Mean Filters, Order Statistics, Adaptive filters, Band reject Filters, Band pass Filters, Notch Filters, Optimum Notch Filtering, Inverse Filtering, Wiener filtering. (6) Color Image Processing: Color image fundamentals - RGB, HSI and CMY models (8)

	Image Segmentation: Contour and shape dependent feature extraction, textural features, region-based and feature-based segmentation and level set method. (10)
Text Books, and/or reference material	Text Books: 1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods 2. Fundamentals of Digital Image Processing by Anil K Jain 3. Digital Image Processing by William K Pratt

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	2	3	2	2
CO2	3	3	3	2	3	2	1	1	2	3	2	2
CO3	3	3	2	2	2	2	1	1	2	3	2	2
CO4	3	3	3	2	2	2	1	2	2	3	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 841	**Nonlinear Dynamical Systems**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: To learn stability analysis of nonlinear transient problems in all fields. CO2: To learn Chaos of nonlinear transient problems using dynamical behaviors (Bifurcations, FFT, Poincare Maps, Lyapunav exponents, Henon maps and Fractals)						
Topics Covered	**One- Dimensional Flow**: Flows on the line, fixed points and stability, linear stability, real life problem and exercises; Flows on circle, Fixed points and stability, real life problem and exercises; Bifurcations: Types of bifurcations, Normal forms of saddle-node, transcritical, pitchfork, Supercritical and Subcritical bifurcations,and imperfect birfercations real life problem and exercises 12 **Two -Dimensional Flows:** Linear system, Definitions and examples, Classification of Linear system, Exercises, Phase plane, Phase portraits, Fixed points and Linearization of nonlinear systems, Exercises, Limit cycles, Definition and understanding with examples, Poincare theory, FFT of time series data, Exercises, Bifurcations of 2-D system, Saddle-node, Transcritical and Pitchfork Bifurcations, Hopf Bifurcations and its type with normal form, Hopf point and fold points, Hysteresis zone, Poincare map, FFT and phase portrait, Exercises 15 **Chaos**: Lorenz Equations, Properties of Lorenz Equations, Lorenz map, Exploring parameter Space, Exercises, One-Dimensional Maps, Fixed points and Cobwebs, Logistic maps, Lyapunov Exponent, Exercises, Fractals, Countable and uncountable sets, Cantor Sets, Dimension of a self, similar Fractals, Box dimension, Point wise Correlation Dimensions, Exercises, Strange attractor, Simplest examples, Henon map, Physical examples, Exercises. 15						

Text Books, and/or reference material	**Text Books:** 1. Nonlinear dynamics and Chaos by S. H. Strogatz
	Reference Books: 1. Chaos and nonlinear dynamics by R. C. Hilborn 2. Differential dynamical systems by J. D. Meiss

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMO841	Material Science	Width Elective	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
PHC01: Engineering Physics, CYC01: Engg Chemistry		CT+EA					
Course Outcomes	CO1: Learn science and technological aspects to a design problem involving materials. CO2: Emphasis is put on such engineering materials which are traditionally and commercially important. CO3: The existing industrial materials problem can be analysed and various techno-economic aspects of materials science.						
Topics Covered	Introduction: Solid Engineering Materials- their classification and characteristic properties.(1) Solidification of pure metals: Homogeneous and Heterogeneous nucleation process, cooling curve, concept of supercooling, microstructures of pure metals. (1) Binary phase diagrams: Isomorphous, eutectic, eutectoid, peritectic, and peritectoid systems, effect of non-equilibrium cooling, coring and homogenization. (2) Iron cementite diagram: Construction and interpretation of Fe-Fe_3C and Fe Graphite diagrams. Microstructure and properties of different alloys in steel and cast iron, their microstructures and typical uses. (2) Physical metallurgy of common non-ferrous alloys: Cu, Al and Ni based alloys. Microstructures and heat treatment of common alloys of these systems. (2) Study of the industrially important steels, their mechanical and thermal treatment and uses: Plain carbon steels, Dual Phase Steels and High Strength Low alloys (HSLA) Steels. (8) Effect of Alloying Elements in Steel. Alloy Steels: Manganese Steels, Hadfield manganese Steel. Heat Resistant and Stainless Steels, Tool and Die Steels, High speed tool steel (HSTS), Maraging Steels. (7) Study of Nonferrous Alloys, their mechanical and thermal treatment: Brasses, Bronzes, Bearing Metals, Light alloys based on Aluminium and Magneium, Titanium Base alloys, Ni base alloys, Lead and tin base babbits. (8) Cryogenic and High temperature Materials, Alloy cast irons, Special purpose materials, such as, Materials for Aerospace, Nuclear Reactors etc. Electrical and Magnetic Materials. (4)						
Text Books, and/or reference material	Text Books: 1. W. D. Callister, Materials Science and Engineering an Introduction, Wiley, 2003. 2. V. Raghavan, Materials Science and Engineering, PHI, New Delhi, (1998). 3. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill. 4. Structure and properties of materials – J Wulff and other. Vols. I–IV. Wiley Eastern pub Ltd. New Delhi 5. Metallurgy for Engineers – E C Rollason 6. Physical Metallurgy – Vijendra Singh. 7. Engineering Materials: H. J. Sharp Haywood, London (1961)						

	8. Engineering Materials: M. F. Ashby and D. R. N. jones, Pergamon press (1980). Reference books: 1. Materials Science and Engineering by Raghavan - Prenctice Hall of India Ltd. 2. Physical Metallurgy of Engineering Materials by N. R. petty, Allen Unwin (1968) 3. Light Alloys: Metallurgy of the light Metals by I. J. Polmser-Edwaraed annord. The Super alloys by C. T. Sims and W. C. Hegel –Wily-Interscience.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3	2	2	2	2	3	2	1	1	1
CO2	1	2	3	1	2	1	2	3	2	1	2	1
CO3	1	1	3	2	2	1	1	3	2	1	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

BASKET – 5

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO850	International Economics and Globalization	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Have a good conceptual understanding of the key concepts and practical applications of international trade and globalization. CO2: Outline the development trade theory historically, differentiating standard classical and orthodox trade theories. CO3: Analyze the links between trade, international finance, economic growth and globalization, with a particular emphasis on the experiences of developing countries. CO4: Critically comment on and participate in current debates on international economic policy.						
Topics Covered	Unit 1: International Trade: Classical Theory -(3 L) Unit 2: International Trade: H-O Theorem -(3 L) Unit 3: International Trade: Factor Endowment Theorem -(3 L) Unit 4: International Trade Policy: Instruments -(3 L) Unit 5: Tariff and Protection -(3 L) Unit 6: Export Subsidy and Import Quota -(3 L) Unit 7: International Monetary Economics: Basics -(3 L) Unit 8: International Monetary Economics: Balance of Payments, Foreign trade Multiplier -(3 L) Unit 9: International Monetary Economics: Devaluation & Absorption Approach -(3 L) Unit 10: International Monetary System: fixed vs. flexible regime -(3 L) Unit 11: International Monetary System: Gold Exchange -(3 L) Unit 12: International Monetary System: IMF and World Bank -(3 L) Unit 13: Globalization -(3 L) Unit 14: Liberalization in Indian Economy -(3 L)						
Text Books, and/or reference material	1. Krugman and Obstfeld, International Economics 2. Sodersten& Reed-International Economics 3. Salvatore – International Economics 4. Mishra & Puri- Indian Economy 5. Datta &Sundaram- Indian Economy 6. Sunanda Sen – Globalization and Development						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	2	3	3	3	2	3	3	3
CO2	2	3	3	2	2	3	3	3	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	2	3	3	2	2	3	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO851	Literature and Cinema	POEL	42	0	0	42	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: To develop students' understanding of texts and their cinematic adaptations. • CO2: To undertake detailed studies as well as analyses of changes or alterations during the conversion of one art-form into another. • CO3: To delve deeper into the relevance, future and scope of cinematic adaptations.						
Topics Covered	• Differences and similarities between Literature and Cinema. (4) • Basics of Cinematic Adaptations (3) • The development of cinematic language as visual narration. (4) • Close reading/watching, analysis, and discussion on Cinematic adaptation I (4) • Close reading/watching, analysis, and discussion on Cinematic adaptation II(4) • Close reading/watching, analysis, and discussion on Cinematic adaptation III(4) • Close reading/watching, analysis, and discussion on Cinematic adaptation IV(4) • Close reading/watching, analysis, and discussion on Cinematic adaptation V(4) • Adaptation/Appropriation /Adulteration (8) • Future of Literature and Cinema (3)						
Text Books, and/or reference material	Suggested Text Books: 1. The Home and the World – Rabindranath Tagore 2. Othello – William Shakespeare 3. Five Point Someone –Chetan Bhagat Suggested Reference Books: 1. Bluestone, George. *Novels into Film*, the John Hopkins Univ Press. 2003. 2. Mandal, Somdatta, *Film and Fiction: Word into Image*, Rawat 2005. 3. Rai, Shri Krishan, and A Raieds. *Adaptations: Some Journeys fromWords toVisuals*, Cambridge Scholars Publishing, 2015. 4. Stam, Robert. *Film Theory: An Introduction*. Oxford Blackwell, 2000.						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2				3	2	2	3	3		2
CO2		3		2		3	2	2	3	3		2
CO3		2	2		2	3			3	2		3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO852	Classics of Literature	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	• CO1: Learners will be acquainted with the variegated aspects of life represented through literature • CO2: Learners will be able to critically appreciate a piece of literary work acknowledged to be a classic • CO3: Learners will be introduced to the sublime beauty of literary language						
Topics Covered	. **Poetry (any five to be selected by the Instructor):** William Shakespeare: Sonnet No. 73/ Sonnet No. 116 / Sonnet No. 118 John Donne: The Canonization / The Extasie Andrew Marvell: To His Coy Mistress / The Garden William Wordsworth: Upon Westminster Bridge / Tintern Abbey P. B. Shelley: The Cloud / Ode to the West Wind John Keats: Ode on a Grecian Urn/ Ode to a Nightingale / Bright Star Lord Alfred Tennyson: Break, Break, Break / Ulysses / Tithonus Robert Browning: My Last Duchess / Two in the Campagna Matthew Arnold: Shakespeare / Dover Beach W. B. Yeats: The Second Coming /Sailing to Byzantium T. S. Eliot: The Love Song of J. Alfred Prufrock /Preludes **B. Play (one to be selected by the Instructor):** Christopher Marlowe: Doctor Faustus / William Shakespeare: Julius Caesar / William Shakespeare: Macbeth / William Shakespeare: Hamlet / William Shakespeare: Othello / William Shakespeare: King Lear /William Shakespeare: As You Like It / William Shakespeare: Twelfth Knight /Bernard Shaw: Arms and the Man / Girish Karnad: Hayavadana /John Galsworthy: Justice / St. John Ervine: Progress / T.S. Eliot: Murder in the Cathedral / Samuel Beckett: Waiting for Godot / John Osborne: Look Back in Anger / Harold Pinter: The Birthday Party **C. Novel (one to be selected by the Instructor):** Charles Dickens: Hard Times / Thomas Hardy: The Mayor of Casterbridge / E M Forster: A Passage to India / Joseph Conrad: Heart of Darkness / William Golding: Lord of the Flies / Graham Greene: The Power and the Glory / James Joyce: A Portrait of the Artist as a Young Man/ George Orwell: Animal Farm						
Text and/or Books	Text Book: As recommended by the Instructor from time to time						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	-	3	3	3	3	3	2	3
CO2	1	3	2	2	1	-	-	1	-	3	-	3
CO3	1	-	-	-	-	-	3	-	-	3	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities & Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSO853	Public Speaking	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA
Course Outcomes	• CO1: Learners will have a good grasp of the basic skills to present a speech that is effective, natural, and beneficial for both the speaker and the audience. • CO2: Learners will develop their communicative skills and the ability to connect deeply with another human being on the societal plane. • CO3: Learners will be equipped with a basic understanding of speech research, organisation, and delivery.
Topics Covered	1. Communicating with Others (4) 2. Giving Yourself Permission (4) 3. Organising Your Speech (4) 4. Selecting Your Topic (4) 5. Gathering Your Material (4) 6. Listening to Others (4) 7. Delivering Your Speech (4) 8. Informing Your Audience (5) 9. Persuading Your Audience (5) 10. Speaking for Your Lifetime (4)
Text Books, and/or reference material	Text Book: 1. *The Natural Speaker*. 8th Edition. Randy Fujishin. Routledge.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	2	-	-	-	2	3	1	-	3
CO2	1	-	-	2	-	3	3	2	-	3	-	3
CO3	2	1	1	2	3	-	-	-	-	2	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

DEPARTMENT OF MANAGEMENT STUDIES							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO8 51	INVESTMENT MANAGEMENT AND STOCK MARKET	PEL	3	0	0	3	3
Pre-requisites- NIL		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To learn about investment decision process and various investment avenues CO2: To understand about Stock / capital market CO3: To learn about equity valuation tools and techniques CO4: Portfolio Management process and risk and return analysis						
Topics Covered	**UNIT I:** Introduction to various investment avenues and alternatives, Investment vs gambling and speculation, Types of investors and avenues, New Issue market and Stock Exchanges, Trading mechanisms in stock exchange- **(5)** **UNIT II:** Equity Valuation: Macroeconomic Analysis Industry Analysis; Company Analysis; Valuation of Equity Shares- (10) **UNIT III:** Fixed Income Security Analysis: Bond Prices and Yield (3) **UNIT IV:** Technical Analysis (6) **UNIT V:** C Risk Vs Return Efficient Market Hypothesis. Capital Market Theories: CAPM, CML, SML, Efficient frontier with Riskless lending and borrowing, Markowitz Model, Sharpe single index Model) Portfolio Risk & Return Factor Models and Arbitrage Pricing Theory (8) **UNIT VI**: Portfolio Management -Portfolio Evaluation and Behavioural Finance Portfolio revision (2) **Unit VII**- Derivatives Market (6)						
Text Books, and/or reference material	Text Books: 1. Investment Analysis and portfolio Management- P Chandra TMH 2. Security Analysis and Portfolio Management - Donald E. Fischer, Ronald J. Jordan 3. Value investing and Behavioural Finance, Parikh, TMH 4. Investment Management – V.K. Bhalla – S. Chand 5. Investment Management and Security Analysis – D.K. Khatri – Mcmillan						

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSO 852	INDUSTRIAL MARKETING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NIL		CT+EA					
Course Outcomes	• CO1: Understand the importance of industrial marketing • CO2: Analyse industrial consumer behaviour						

	• CO3: Formulate effective industrial marketing strategies
Topics Covered	1. Understanding industrial marketing Company's vision and industrial marketing, market paradigms, business assumptions, understanding industrial customer orientation, the customer-product relationship, customer orientation through the product, competitive behaviour in industrial markets (10). 2. Understanding industrial products What is an industrial product? Types of industrial product, nature of industrial product, commodity marketing, industrial product functionality, industrial product life cycle (5). 3. Exploring industrial markets Identifying industrial consumer need, purchase behaviour of an industrial customer, industrial purchasing process, factors influencing industrial purchase decisions, industrial marketing research process (5). 4. Industrial market segmentation Need for segmentation, different bases of segmenting industrial markets, process of segmentation of industrial markets (3). 5. Industrial product design and development Turning customer needs into product/service, process of product development, adoption process of industrial products (3). 6. Organizing marketing and sales department of an industrial company Organizational structure of an industrial sales force, organizational structure of an industrial marketing department, cross-selling industrial products (3). 7. Industrial sales force Purpose of an industrial sales force, industrial selling process, role of a sales engineer, consultative sales management for complex industrial products, industrial sales force compensation (3). 8. Distribution of industrial products Characteristics of industrial distribution, types of industrial distribution, key issues in designing industrial distribution (3). 9. Industrial branding Different types of industrial brands, factors affecting industrial branding, principles of industrial branding (2) 10. Pricing industrial products Challenges in industrial price management, a general model for price determination of industrial products, key issues in value based pricing (3). 11. Promotion strategies for industrial products Advertising, the COMPACT model, other forms of promotion strategies for industrial products (2).
	Text Book: The Marketing Challenge for Industrial Companies: Advance Concepts and Practices, Claudio A Saavedra, Springer, 2016. Reference Books: 1. Industrial Marketing, P. K. Ghosh, Oxford University Press, 2005. 2. Industrial Marketing, Ronald McTavish and Angus Maitland, The Macmillan Press, 1980

CO-PO mapping matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO#1											2	3
CO#2				1					2		2	3
CO#3						2			2		2	3

Department of Mathematics

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours: Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	Credit
MAO851	Operations Research	PEL	3	0	0	3	3

Pre-requisites	Basic concepts of Set Theory, Linear Programming Problem, Network and Game Theory
Course Outcomes	• CO1: To understand the origin of Operations Research and &to familiarise with formulation of different Problems. • CO2: To acquire knowledge on fundamentals of Linear Programming and also to learn its applications. • CO3: To get basic knowledge on fundamentals of Netwok Analysis so as to get acquainted with designing & planning of various project related problems. • CO4: To get the basic Concepts of decision making under competitive situations.
Topics Covered	**Overview of Operations Research:** Origin of OR and its definitions, Formulation of the OR problems, Developing OR models, Testing the adequacy of the model, Model solution, Evaluation of the solution and implementation. (4) **Linear Programming and its Applications:** Vector spaces, Basis, Linear transformations, Convex sets, Extreme points and convex polyhedral sets Theory of Simplex method, Simplex Algorithm, Degeneracy, Duality theory, primal dual algorithms, Transportation problems, Assignment problems, Sensitivity analysis. (14) **Network Analysis:** Introduction to network analysis, Shortest path problem, Construction of minimal spanning tree, Flows in networks, Maximal flow problems. Definition of a project, Job and events, Construction of arrow diagrams, Determination of critical paths and calculation of floats. Resource allocation and least cost planning, Use of network flows for least cost planning. Uncertain duration and PERT, PERT COST system. Crashing. (12) **Game Theory:** Maxmin and Minmax principle, Two-person Zero-sum games with saddle point, Game problems without saddle point, Pure strategy and mixed strategy, Solution of a 2×2 game problem without saddle point, Graphical method of solution for n×2 and 2×n game problem, Reduction rule of a game problem (Dominance rule), Algebraic method of solution of game problem without saddle point, Reduction of a game problem to linear programming problem. (12)
Text Books, and/or reference material	**Text Books:** 1. J. K. Sharma: Fundamentals of Operations Research, Macmillan. 2. F.S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995. 3. Ravindran, Philips, Solberg, Operations Research Principles and Practices, Wiley India Edition. **Reference Books:** Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research- An Introduction, S. Chand & Company. 2. Anderson, D. R., Sweeney, D. J. and Williams, T. A., An Introduction to Management Science, St. Paul West Publishing Company, 1982. 3. Sharma, S. D., Operations Research, Kedar Nath & Ram Nath, Meerut, 1995. 4. H. A. Taha, Operations Research –An introduction, PHI

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
MAO851	CO1	2	3	2	2	1	1	1	-	-	-	1	2
	CO2	2	3	2	1	1	2	2	-	1	2	2	2
	CO3	3	3	2	3	1	-	1	-	2	2	2	2
	CO4	2	2	3	1	2	2	2	1	2	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours (Per week)				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO852	Advanced Numerical Analysis	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basics of Linear Algebra & Numerical Methods		CT+EA					
Course Outcomes	• CO1: Develop problem solving skills by different numerical methods and also skill in numerically verifying theoretical convergence speed. • CO2: Help to work with key concepts of stability and assessing the accuracy of numerical results. • CO3: Help to write algorithm, computational steps & flow chart which help in developing computer program. • CO4: Help to solve various scientific and engineering problems by different numerical methods.						
Topics Covered (with lecture hours)	Numerical solution of Algebraic and transcendental equations (Method of Iteration, Newton-Raphson method), convergence and errors. (3) Solution of system of equations by Direct method (Gauss-elimination, Gauss Jordon, L-U decomposition) and Iteration method (Jacobi, Gauss-Seidel), Convergence analysis and errors. (7) Eigen values and Eigen vectors by power method. (3) Interpolation- Newton's divided difference, cubic spline, Hermite poly, error in interpolation, Least square approximation. (6) Numerical differentiation and integration (Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule), Error analysis. (5) Numerical solution of ordinary differential equations (Taylor series method, Euler's & Modified Euler's method, Runge-Kutta method), Finite difference solution of boundary value problem. (9) Numerical solution of partial differential equations of hyperbolic (wave equation), parabolic (heat equation), elliptic (Laplace and Poisson equation)(9)						
Text Books, and/or reference books	**Text Books:** 1. Introductory Methods of Numerical Analysis- S.S.Sastry (PHI). 2. Numerical Methods for scientific & Engineering Computation- M.K. Jain, S.R.K. Iyengar & R.K. Jain (New Age International (P) Ltd.). **Reference Books:** 1. Numerical Mathematical Analysis- J.B. Scarborough (Oxford & IBH). **2.** A friendly introduction to Numerical Analysis, Braine Bradie, Pearson Edu.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO 1**	**PO 2**	**PO 3**	**PO4**	**PO5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
MAO852	CO1	3	3	2	2	3	1	2	-	-	3	1	2
	CO2	2	3	2	2	1	2	1	1	1	2	1	2
	CO3	2	2	1	1	-	-	1	-	-	1	-	2
	CO4	3	2	2	2	2	2	2	-	2	3	2	3

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAO853	Optimization Techniques	PEL	3	0	0	3	3
Pre-requisites		Vector Spaces and Matrices, Linear Transformations, Eigenvalues and Eigenvectors					
Course Outcomes	• CO1: Ability to develop a knowledge in the field of optimization techniques and their basic concepts, principles and algorithms. • CO2: Ability to understand fundamentals of linear programming, Integer programming and Dynamic programming. • CO3: Ability to apply the theory of optimization methods for modelling various types of decision making problems. • CO4: Ability to solve the mathematical results and numerical algorithms of optimization theory to concrete Engineering and Management problems.						
Topics Covered	**Basic Concepts:** Formulation of mathematical programming problems; Classification of optimization problems; Optimization techniques – classical and advanced techniques (5) **Optimization using Calculus:** Convexity and concavity of functions of one and two variables; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation (7) **Linear Programming:** Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Graphical method for two variable optimization problem; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Revised simplex method; Duality in LP; Primal dual relations; Dual Simplex Method; Sensitivity or post optimality analysis; bounded variables; Examples for transportation, assignment, TSP problems. (18) **Dynamic Programming:** Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality (8) **Integer Programming:** Integer linear programming; Branch and Bound algorithm; Concept of cutting plane method; Mixed integer programming; Solution algorithms. (8) **Advanced Topics in Optimization:** Direct and indirect search methods; Heuristic and Meta-Heuristic Search methods; Multi objective optimization. (10)						

Text Books, and/or reference material	**Text Books:** 1. Singiresu S. Rao, *Engineering Optimization -Theory and Practice,* New Age International (P) Limited, New Delhi, 2000. 2. H.A. Taha, *Operations Research: An Introduction*, 5th Edition, Macmillan, New York, 1992. A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, *Engineering Optimization-Methods and Applications,* Wiley-India Edition, New Delhi, 2002. **Reference Books:** 1. R. Fletcher, *Optimization,* Academic Press, 1969. 2. 2. K. Deb, *Optimization for Engineering Design Algorithms and Examples*, Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
MAO853	CO1	2	3	3	2	1	1	2	-	1	-	1	1
	CO2	2	2	3	1	2	-	3	-	1	-	2	1
	CO3	3	2	2	2	2	-	2	-	1	1	2	2
	CO4	3	2	3	3	2	-	3	-	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO 851	**Fiber-Optics Communication**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))
NIL	CT+MT+EA

Course Outcomes	After completion of the course, the student is able to **CO1:** Distinguish and identify different types of fibers and there potential application in different fields of optical communication and sensing. **CO2:** Explain different characteristics of optical fiber along with dispersion and attenuation. **CO3:** Understand and classify the working principle of different optical sources and detectors. **CO4:** Acquire basic knowledge of short haul, long haul and advanced optical transmission systems.
Topics Covered	**Introduction to Optical Fiber Communications:** Transmission speed, Evolution of Fiber Optic Systems, Elements of an Optical Fiber Transmission Link. [3] **Optical Fibers: Structures, Waveguide and Fabrication:** Ray propagation through SI and GI fiber, Pulse broadening- multipath dispersion and material dispersion, Maxwell's Equations, TE and TM mode wave equations. Wave propagation in rectangular slab and circular waveguides, Propagation modes, Power Flow in rectangular slab waveguide, Single-mode fibers; Mode-field diameter. Fiber fabrication; overview of different methods of fabrication. [14]

	Signal Degradation in Optical Fibers: Signal attenuation, Absorption, Scattering Losses, Bending Losses, Core and cladding losses, coupling loss. Group Velocity Dispersion, Material Dispersion, Waveguide Dispersion, Polarization-Mode dispersion, Intermodal Distortion. **[7]** **Optical Sources and Detectors:** Review of semiconductor Physics. Light Emitting Diodes (LEDs); Structure, Materials, Quantum Efficiency and LED Power, Modulation of an LED. Laser Diodes; Threshold conditions, Rate equations, Quantum efficiency, Resonant frequencies, Structure and radiation patterns, Single-mode lasers, Modulation, Effects of temperature. Optical detectors- p-n junction, P-I-N, APD, Phototransistor, PMT detectors. [12] **Power launching and coupling:** Source-to-Fiber power launching lensing schemes for coupling improvement, Fiber splicing, Optical fiber connectors and optical devices, etc. [6]
Text Books, and/or reference material	**TEXT BOOKS:** **1.** Fiber Optics and Optoelectronics, R. P. Khare, Oxford University Press 2. Optical Fiber Communications (3rd Ed.), Gerd Keiser- McGraw-Hill 3. Optoelectronics Photonics , S.O. Kasap **REFERENCE BOOKS:** 1. Introduction to Fiber Optics, Ajoy Ghatak & K. Thyagarajan, Cambridge University Press 2. Fiber-Optic Communications Technology, D. K. Mynbaev & L. L. Scheiner, Pearson Education 3. Optical Communication Components & Systems, J. H. Franz & V. K. Jain.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
PHO 851	CO1	3	1	1	1		2	2	1	1	1	1	1
	CO2	2	2	2	1	1	1	1	1	1	1	1	2
	CO3	2	2	3	2	2	1	1	1	2	1	1	1
	CO4	2	2	2	1	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHO852	**Optical Instrumentation**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize fundamental concepts of optics such as reflection, refraction and diffraction in designing optical elements. CO2: To learn basics and working principle of some optoelectronic devices. CO3: To gain an integrative overview and applications of different optical microscopes, telescopes and spectroscopes.						

	CO4: To acquire fundamental knowledge of interferometry and apply it in optical metrology.
Topics Covered	**Optical elements**: Reflective and Refractive optical elements, Diffractive optical element, Holographic Optical Element, Grating, Prism. [6] **Microscopy**: Bright field microscopy, Dark field microscopy, Phase-Contrast microscopy, Polarized light microscopy, Differential Interference contrast microscopy, Fluorescence microscopy, Confocal microscopy, Digital Holographic microscopy. [8] **Spectroscopy:** Atomic Absorption Spectroscopy, UV-Vis-NIR Spectroscopy. [4] **Optical Interferometer:** Common path interferometer, Multiple-Beam interferometer, Multiple wavelength interferometer, Shearing interferometer, Speckle interferometer. [6] **Optoelectronic devices**: Photomultiplier Tubes, Photodiodes, CCD, acousto-optic modulator, electro optic modulator [6] **Optical Instruments**: Optical Coherence Tomography, Particle Image Velocimetry. [6] **Optical Metrology**: Moire, fringe projection, Holography and Speckle techniques. [6]
Text Books, and/or reference material	**TEXT BOOKS** 1. Optical Shop Testing, D. Malakara, Wiley & Sons, Inc. 2007. 2. Practical Holography, G. Saxby, CRC Press, 2017. 3. Materials Characterization, Yang Lang, Wiley-VCH, 2013. **REFERENCE BOOKS** 1. Fundamental of Photonics, B. E. A. Saleh, M. C. Teich, Wiley, 2007. 2. Optics, E. Hecht, Addison-Wesley, 2001. 3. Optics, A. Ghatak, Tata McGrawHill, 2005.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	**COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
PHO 852	CO1	3	2	2	2	1	1	1	1	1		1	1
	CO2	3	1		1	1							1
	CO3	3	2	2	2	1	1	1	1	1		1	1
	CO4	3	2	2	2	2	1	1	1	1		1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO850	Medical Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	· CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence. · CO2: Able to analyze the key features therapeutics and drugs in current scenario. · CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals. · CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.
Topics Covered	**Microbial pathogenesis:** Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics. **Diagnosis of Infectious diseases**–Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy. **DrugDesign and Drug delivery system :** Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques . New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics **Molecular Medicine:** Antibodies and vaccines-Therapeutic production of antibodies, different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection . **Cell and tissue therapy** – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery **Clinical Toxicology**,**Clinical Research Governance and Ethics:** Basic concept in toxicology. Types and mechanism of toxin action-Epoxidation & drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. . International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press 2. Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons 3. S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers 4. Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA <u>Suggested Reference Books:</u> 1. Pharmaceutical Biotechnology ; Sambhamurthy&Kar , NewAge Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate 4. Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

Mapping of CO (Course Outcome) and PO (Programme Outcome):

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	2	2	1	-	-	-	-	-	2
CO2	2	1	1	-	1	1	-	1	-	1	-	2
CO3	2	1	1	1	1	1	-	1	-	1	1	2
CO4	2	1	1	1	1	2	2	2	1	1	2	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO850	**Watershed planning & Management**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Fluid Mechanics, Irrigation & Water Resources Engineering, Economics and Computer Applications	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	· CO1: A clear understanding of different aspects of watershed · CO2: Development of capabilities for optimization techniques, linear and dynamic programming for watershed management · CO3: Development of ability to formulate model for watershed planning with deterministic as well as stochastic inputs,
Topics Covered (Hrs)	**Introduction**: Concept, Definition & Scope, Indian & Global Perspective, Timeline in India, Problems & Prospects, Problems & Constraints **(4)** **Land Capability & Planning**: Definition, Classification, Planning, Use, Restoration, Policy Analysis & Decision Support **(3)** **Watershed Characteristics:** Physical & Geomorphologic Factors, Classification & Measurement, Physical, Geomorphologic & Quantitative Characteristics **(4)** **Importance of Watershed Properties:** Watershed Management, Effect of Physical Properties, Effect of Geomorphologic Factors & Associated Processes **(4)** **Hydrologic Data**: Definition, Scope, Hydro-meteorological & Physiographical Data **(3)** **Delineation and Prioritization**: Concept of Topographic or Contour Map, Boundary Delineation, GIS for Delineation, Accuracy in Delineation, Concept of Priority, Factors, Basics & Methods, Purpose & Benefits **(4)** **Water Yield Assessment & Measurement**: Concept of Water Yield & its assessment, benefits, Perspectives, Measurement, Modelling & Assessment **(3)** **Hydrologic and Hydraulic Design**: Hydrologic design, recharge structures, Earthen Embankments & Diversion Structures, Hydrology & Hydrologic design **(5)** **Soil Erosion and its Control Measures**: Types, Problem & Control **(4)** **Sediment Yield Estimation**: Generation & Transport Mechanism, Types Methods Estimation & Modelling, Estimation of Different Load **(4)**

	Rainwater Conservation & Harvesting: Need, Techniques, Design **(4)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Watershed management challenges: Introduction and overview by E. R. Sharma & C. A. Scott, (2005), Watershed Management Challenges: Improving 2. Land and Water Management Engineering by V. V. N. Murthy & M. K. Jha, (2011), Kalyani Publishers, Ludhiana, India. 3. Watershed Management- Guidelines for Indian Conditions by E. M. Tideman, (1999), Omega Scientific Publishers, New Delhi. 4. Integrated Watershed Management in Rainfed Agriculture by S. P. Wani, J. Rockström & K. L. Sahrawat, (2011). CRC Press. ***Reference Books:*** 5. http://www.ussi.co.uk/Weirs_and_Flumes.html. Last seen: 29th September 2013

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO10	PO11	PO1 2
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	3	3	3	3	3	-	-	-	-	-
CO3	-	-	3	-	-	-	-	3	3	3	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO851	**Elementary Structural Design**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering /Solid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	· CO1: Apply knowledge of solid mechanics for design solutions. · CO2: Understand basic design philosophy applicable to steel structures. · CO3: Formulate, analyze, and design basic components of Civil Engineering Steel structures.						
Topics Covered (Hrs)	**Properties** of Reinforced Concrete and Structural Steel, Loads & load combinations, Design Philosophies-Working Stress Method, Limit State Method **(4)** **Limit State Method (LSM) of design for RC Structures:** Limit State of Flexure: Stress-strain characteristics of concrete & reinforcing steel, Moment of Resistance for singly reinforced, doubly reinforced sections. Limit State of Shear, Bond & Anchorage, Development length, Design of Beams, slab, Short Columns under axial load, Design of isolated Footing. **(19)**						

	Limit State Method (LSM) of design for Steel Structures: Limit state of collapse & serviceability, partial safety factor for material and loading, Connections: truss joint connections, Design of Tension member, Compression member, Design for Beams, Gusseted Column base foundation **(19)**
Text Books, and/or reference material (s)	***Text Books:*** 1. Reinforced Concrete Design by S. U Pillai and Devdas Menon, Tata McGraw-Hill. 2. IS 456: 2000, Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi. 3. Design of steel Structures by N. Subrhamanium (Oxford publications) 4. IS 800-2007: General Construction in Steel-Code of Practice 5. IS 808-1989: Dim of Hot Rolled Steel beam, column, channel and angle sections 6. www.nptel.iitm.ac.in/courses/ ***Reference Books:*** *7.* Reinforced Concrete Design by S.N. Sinha, Tata McGraw-Hill Publishing*:* 8. Limit State Design of Steel Structures by S.K. Duggal, McGraw Hill publications

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	2	-	-	-
CO2	3	-	3	-	-	-	1	-	-	2	-	2
CO3	-	2	3	-	-	-	-	2	-	2	2	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CEO852	**Reliability Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Engineering Mathematics		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes (COs) :	· CO1: Apply the concepts of probability and statistics in reliability analysis. · CO2: Aanalyze data for finding failure probability. · CO3: Apply Monte carlo simulation technique in reliability analysis to solve different engineering problems. · CO4: Develop the concepts of statistical quality control and reliability tests.						
Topics Covered (Hrs)	**Elements of probability and statistics**: Basictheory of probability, random variable, functions of random variables, multiple random variables, Joint PMF, PDF, CDF, Conditional probability, Probability distributions (discrete and continuous), basic statistics, covariance and correlation. (8) **Failures of Engineering systems**: Data analysis, Hazard models. (4) **Basic reliability analysis**: Introduction, Definition of reliability, Different						

	classical reliability analysis methods: First Order Reliability Method, Second Order Reliability Method, Engineering applications. (10) **Simulation Techniques**: Monte Carlo simulation technique, theory and applications. (4) **Statistical Quality Control and Reliability Tests:** Statistical Quality Control, Statistical Reliability Tests, Accelerated Testing, Goodness of fit tests. (8) **System reliability**: Modeling, parallel and series system, Reliability improvement and allocation. (6)
Text Books, and/or reference material(s)	**Text Book(s)** 1. Probability concepts in engineering and design by Ang and Tang, John Wiley. 2. Probability, reliability and statistical methods in engineering design by A. Halder and S. Mahadevan, John Wiley and Sons. New York. 3. Probability, random variables and stochastic processes by A. Papoulis, McGraw Hill New York. ***Reference Book(s):*** 4. Practical Reliability Engineering by Patrick O'Connor, Andre Kleyner, John Wiley and Sons, New York.

Mapping of Course Outcomes Cos → POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	1	2	-	3	-	-	-	-	-	-	-	-
CO3	-	-	2	2	-	-	-	-	-	-	-	-
CO4	-	-	2	1	-	-	-	-	-	-	-	-

Department of Chemical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHO851	**ENERGY, ENVIRONMENT & SUSTAINABILITY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CHC401		CT+EA					
Course Outcomes	• CO1: Learn about energy technology of different conventional and non-conventional energy resource and Recent worldwide energy market scenario • CO2: Design & analyze of different renewable energy collectors and renewable energy thermal power plants • CO3: Learn industrial and domestic applications of different renewable energy sources • CO4: Solve energy technology problems of different difficulty levels through tutorials						
Topics Covered	**Module I:** Wind Energy: Sources and potentials, Wind energy conversion, General formula - Lift and Drag- Basis of wind energy conversion – Effect of density, frequency						

	variances, angle of attack, and wind speed. Windmill rotors Horizontal axis and vertical axis rotors. Determination of torque coefficient, horizontal and vertical axis windmills, performance characteristics, Betz criteria, Design and analysis of wind turbines. geographical aspects. [10 hrs.] **Module II:** Solar Energy: Energy available form Sun, Solar radiation data, Solar energy conversion into heat, Flat plate and Concentrating collectors, Construction and performance analysis of solar flat plate collectors, Mathematical analysis of Flat plate collectors and collector efficiency, collector efficiency factor, tilt factors, collector heat removal factor, Hottel-Willier-Bliss equation. Principle of Natural and Forced convection, Salt gradient solar ponds: construction, operation, technical problems, Solar drying and dehumidification: Solar cabinet dryers, convective dryers Solar engines-Stirling, Brayton engines, Photovoltaic, p-n junction, solar cells, PV systems, Stand-alone, Grid connected solar power satellite. [10 hrs.] **Module III:** Nuclear Energy: Nuclear fission principles, types of nuclear reactors (BWR, PWR, PHWR, LMCR, GCR, FFR). Nuclear reactor analysis: four factor formula, resonance absorption, reactor buckling, multiplication factor, thermal utilisation coefficient, reflector saving, fast fission factor, optimum moderator to fuel ratio. Radioactive waste disposal **Energy from Ocean:** Wave, Tidal and OTEC energy- Difference between tidal and wave power generation, Principles of tidal and wave power generation, OTEC power plants (closed cycle, open cycle, hybrid cycle), operation and technical problems, environmental impact, Tidal power, salinity power plants, **Geothermal systems:** Resources, types of wells, methods of harnessing the energy, Hot water and dry steam systems, energy extraction principles. [10 hrs.] **Module IV:** **Energy from biomass:** Biomass utilization: pyrolysis, gasification, anaerobic digestion (biogas production). Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, Biodiesels: Manufacture and characteristics. **Gasohol:** Characteristics and manufacture, use of pervaporation technology. Synthetic liquid fuels from coal: F – T Process, Coal hydrogenation, MTOG process. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. Ashok V Desai, Non-Conventional Energy, Wiley Eastern Ltd, New Delhi, 2003 2. K M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, New Delhi, 2003. Suggested Reference Books: 1. Ramesh R & Kumar K U, Renewable Energy Technologies, Narosa Publishing House, New Delhi, 2004 2. Wakil MM, Power Plant Technology, McGraw Hill Book Co, New Delhi, 2004. 3. G. D. Rai Non – Conventional Energy Sources. Khanna Publication 4. S P Sukhatme and J K Nayak, Solar Energy, McGraw Hill Book Co, New Delhi 4th Edition, 2017

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	3	2	2	1	1	1	1	1
CO3	3	3	3	3	3	2	2	1	1	1	1	1
CO4	3	3	3	3	3	2	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 851	Machine Learning	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
Basic concept of Probability and Statistics.		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	• CO1: Understanding of the basic concepts, fundamental issues and challenges of machine learning. • CO2: Comprehend the principle and techniques of supervised learning. • CO3: Explain the basic concepts and techniques of unsupervised learning. • CO4: Understanding of the basic concepts and challenges of reinforced learning. • CO5: Ability to apply the concepts of machine learning in different domains.						
Topics Covered	1. Introduction: what is Machine Learning; Human learning and Machine learning; Well-posed learning problem; Types of Machine Learning: Supervised, Unsupervised, and Reinforcement learning; Applications, Issues, and tools of Machine Learning. (03 L) 2. Concept Learning: Inductive learning hypothesis, general to specific ordering of hypothesis; FIND-S algorithm; Version space, candidate elimination algorithm; Inductive bias. (04 L) 3. Bayesian Learning, Naïve Bayes Classifier, Optimal Classifier. (03 L) 4. Supervised learning: Classification- k-Nearest Neighbour, Decision Tree, Support vector machine. Regression- Simple and Multiple linear regression. (12L) 5. Artificial Neural Networks: Biological neuron and artificial neuron, How ANN works, Parallel distributed model of ANN; Activation functions; Perceptron, McCulloch-Pits model, ADALINE network model; Architecture of ANN- single-layer feed forward, multi-layer feed forward, competitive network, recurrent network; Backpropagation algorithm; Basic concept of deep learning. (05L) 6. Unsupervised learning: Different clustering techniques- Partitioning methods (k-means, k-medoid, etc. clustering techniques), Hierarchical methods (Agglomerative and Divisive techniques: MIN, MAX, Group average, Ward's etc. methods), and Density-based method (DBSCAN). (05 L) 7. Unsupervised learning: Rule mining and Association analysis- different terminology (itemset, support count, support, association rule, confidence, etc.); Association rule mining techniques; Market-Basket analysis; Apriori principle, Apriori algorithm for frequent itemset generation, Rule generation for apriori algorithm. (05 L) 8. Genetic Algorithm based Learning. (02 L) 9. Reinforcement Learning: Basic concept, Model based learning, Temporal difference based learning. (03 L)							

	10. Standards: Introduction to standardization efforts IS/ISO/IEC/22417 and 20546 (2L)
Text Books, and/or reference material	Text Books: 1. Machine Learning by Tom Mitchell [Mc. Graw-Hill]. 2. Machine Learning by S. Dutt, S. Chandramouli, and /A. K. Das [Pearson, 2019]. 3. Applied machine Learning by M. Gopal [Mc. Graw-Hill, 2018]. 4. NPTEL Course materials. **Reference Books:** Introduction to Machine Learning by Ethem Alpaydin [MIT Press].

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	2	3	2	1	2	3	3	3
CO2	2	2	3	3	3	3	2	2	2	2	3	3
CO3	2	2	3	3	3	3	2	2	2	2	3	3
CO4	2	2	3	3	3	3	2	2	2	2	3	3
CO5	1	3	3	3	2	3	2	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 852	**Data Analytics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Classify the labelled dataset into different classes and group the unlabelled dataset into different clusters by uncovering hidden patterns and correlations among them.. • CO2: Model a problem into a graph database after absorbing and connecting a large volume of data and performing the analytical task over the graph. • CO3: Develop a recommendation system by predicting users' preferences based on similarity measures and evaluating its performance using the metrics such as Precision, recall, and F1-score. • CO4: Understand and set up the Hadoop framework, which will allow them to efficiently manage and process big data in a distributed computing environment.
Topics Covered	Introduction to Data Analytics, Types of Data Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, and Prescriptive Analytics. Use Cases, Issues and Challenges in Big Data Analytics. (4L) Fundamentals of Statistics: Population, Sample, Parameter, Statistic, Variable. Descriptive Statistics, Inferential Statistics. Basic Probability Theory: Random Experiment, Sample Space, Random Variables, Probability, Conditional Probability, Independence, Conditional Independence, Expectation, Variance, Probability Distribution, Joint Probability Distribution, Conditional Probability Distribution. (8L) Similarity Measures: Jaccard Similarity, Cosine Similarity, Adjusted Cosine Similarity. Missing Value Prediction Techniques: Mean Centering, Weighted

	Average, Z-Score. (6L) Basics of Complex Network: Scale-Free Networks, Small-World Phenomenon, Degree Distributions, Transitivity or Clustering. Centrality Measures: Degree Centrality, Betweenness Centrality, Closeness Centrality, Eigenvector Centrality, PageRank Centrality. Community Structure, Community Detection Algorithms: Girvan-Newman, Fast Greedy, Label Propagation, Clique Percolation Method. Community Quality Metrics: Modularity, NMI, Conductance. (10L) Introduction to Data Mining, Machine Learning Techniques: Least Square Regression, Decision-trees, SVM. Clustering Techniques: K-Means. (8L) Introduction to Hadoop Ecosystem – HDFS, Map-Reduce, PIG, HIVE, HBase, Mahout, Zookeeper, Flume, Sqoop, etc. (6L)
Text Books, and/or reference material	**Text Books:** 1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data – EMC Education Services – Wiley. 2. Machine Learning: Hands-On for Developers and Technical Professionals – Jason Bell – Wiley. **Reference Books:** 1. Networks: An Introduction – M. E. J. Newman – Oxford University Press. 2. Hadoop: The Definitive Guide – Tom White – O'Reilly.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	-	-	-	2	-	1	-	-
CO2	3	3	3	3	-	1	2	-	2	2	3	
CO3	3	3	3	3	1	1	3	-	2	2	3	1
CO4	2	2	1	1	3	3	1	2	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO853</td><td>Distributed Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="2">Operating Systems, Computer networks.</td><td colspan="6">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To explain the paradigm of distributed computing.
• CO2: To explore various existing and possible architectures of distributed systems.
• CO3: To properly appreciate the issues that arise in distributed systems and explore solutions for the problems.
• CO4: To fully appreciate the advantages to be obtained from a distributed environment wrt fault tolerance, load sharing etc.</td></tr>
</table>

Topics Covered	Introduction to Distributed Systems. Motivations. Design Issues. (3L) Clocks in a Distributed System. Synchronization Issues. Logical Clocks. Causal relationships. Vector Clocks. (3L) Distributed State Detection. Global State. Consistent Cut. Global State recording algorithm. (2L) Termination Detection. Credit based algorithm. Diffusion Computation based algorithm. (2L) Distributed Mutual Exclusion. Token based and non-token based algorithms. (4L) Deadlocks in Distributed Systems. Resource allocation Models. Deadlock Prevention. Deadlock Avoidance – Safe states. Deadlock detection and Correction. Phantom Deadlocks. Centralized, Distributed and Hierarchical deadlock detection algorithms (5L) Fault recovery. Classes of Faults. Backward and Forward recovery. Log based recovery. Checkpoints. Shadow paging. (5L) Fault Tolerance. Data Replication. Quorum Algorithms . Distributed Commit Protocols. 2-phase commit. 3-phase commit. Election Algorithms. Bully algorithm. Ring topology algorithm. (8L) Byzantine faults and Agreement Protocols. (2L) Distributed File systems. Mechanisms. Stateful and Stateless servers. Scalability. Naming and Name Servers. (4L) Distributed Scheduling. Load Balancing. Load Estimation. Stability. Process Migration. Remote Procedure Calls. Transparency. Binding. (4L)
Text Books, and/or reference material	**Text Books:** Advanced Concepts in Operating Systems. Singhal and Sivaratri. McGraw Hill. **Reference Books:** 1. Operating Systems : A Concept Based Approach. Dhamdhere. McGraw Hill. 2. Distributed Operating Systems : Concepts and Design. P.K.Sinha. Prentice Hall. 3. Distributed Operating Systems. A.Tanenbaum. Pearson Education. 4. Distributed Systems : Concepts and Design. Coulouris et.al. Pearson Education.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	2	3	3	3	-
CO2	3	3	3	3	2	1	1	2	3	3	3	-
CO3	3	3	3	3	2	1	1	2	3	3	3	-
CO4	3	3	3	3	2	1	1	2	3	3	3	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 854	Game Theory and its Applications	PEL	3	0	0	3	3
MAC 01: Mathematics – I, MAC 02: Mathematics - II		Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))					
		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					

Course Outcomes	• CO1: Can have the efficiency to act in a strategic situation. • CO2: Can analyse the strategic interactions among agents. • CO3: Can understand modern state of the art in Game Theory. • CO4: Will have the knowledge of related area where Game Theory can be applied.
Topics Covered	**Introduction:** Motivation to the course. (2L) **Non-Coperative Game Theory:** Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominat Strategy Equilibria, Pure Strategy Nash Equlibrium, Mixed Strategy Nash Equilibrium with examples. (8L) **Mechanism Design without Money**: One sided and two sided matching with strict preferences, Voting theory, and Participatory democracy. (5L) **Mechanism Design with Money:** Auction basics, sponsored search auctions, Revenue optimal auctions, VCG Mechanisms. Online auctions. (6L) **Cooperative Game Theory**: Coalitional Games, The Core, and The Shapley Value. (4L) **Repeated Games:** Introduction to repeated games and its Applications. (4L) **Applications:** Incentive Study in - P2P Networks, Crowdsourcing. (5L) **Some Special Topics**: Fair Division, Price of Anarchy, Scoring rules, Learning in Auction, Synergies between Machine Learning & Game Theory. (8L)
Text Books, and/or reference material	**Text Books:** 1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829. 2. M. Maschler, E. Solan, and S. Zamir. Game Theory, Cambridge University Press; 1st Edition, ISSN: 978-1107005488, 2013. 3. Y. Narahari. Game Theory and Mechanism Design. World Scientific Publishing Company Pte. Limited, 2014, ISSN: 978-9814525046. 4. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791. **Reference Books:** 1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013. 2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016. 3. S. Barman and Y. Narahari, E1:254 Game Theory Course (IISc Bangalore), 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	-	2	2	1	1	1	2	1
CO2	3	3	3	3	1	1	1	-	1	1	2	2
CO3	3	2	3	3	2	2	2	2	1	1	2	3
CO4	1	2	3	3	3	2	2	1	1	1	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSO 855	Information Security	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))
Programming Languages, Computer Networks and Operating Systems	CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**

Course Outcomes	• CO1: Learn fundamental concepts of Information Security viz. Security Models (like the CIA triad), Access Control Mechanisms, Security policies and Security Mechanisms like authentication, identification, authorization, non-repudiation, etc. • CO2: Understand program security issues, attack vectors, and malicious code including worms, viruses, and Trojan horse and logic bombs. • CO3: Understand common vulnerabilities like Buffer Overflow, TOC-TOU flaws. Learn secure programming requirements; write robust security code and exploit/recreate-and-fix common vulnerabilities in software. • CO4: Define trusted computing base and Operating System hardening as defence mechanisms, Intrusion detection and prevention. • CO5: Get introduced to trusted computing and multilevel security. • CO6: Explain concepts related to applied cryptography, including plain-text, cipher-text, four techniques for crypto-analysis, symmetric cryptography, asymmetric cryptography, digital signature, message authentication code, hash functions, and modes of encryption operations. • CO7: Explain and compare security mechanisms for conventional operating systems, OS hardening. Case Study on Linux. • CO8: Exposed to network and distributed systems security issues and solutions including authentication, key distribution and management and network security protocols like SSL/TLS. • CO9: Introduced to Laws and regulatory requirements, security standards and controls, risk management, security metrics and performance indicators, security auditing, education, training and awareness and digital forensics.
Topics Covered	▪ Information Security Introduction -- Defining and Understanding security through security models, Confidentiality, Integrity and Availability, formal description of security, Attacks and Defences, Threats, Vulnerabilities and Risk, Assurance, Prevention, Detection, Security Controls. [2L] ▪ Identification and Authentication. [2L] ▪ Authorization and Access Control, Access Control Models & Mechanisms and Multilevel Security. [2L] ▪ Auditing and Accountability. [2L] ▪ Computational Number Theory & Cryptography -- Fermat's theorem, Euler's theorem, Euclid's algorithm, manually and computationally encrypt/decrypt, sign/verify signatures for small messages using RSA, Deffie-Hellman and DSA algorithms. Applied cryptography viz. Symmetric key Cryptography, asymmetric Cryptography and Digital Signatures, message authentication codes, hash functions and modes of cryptographic operations.[6L] ▪ Physical Security. [1L]

	▪ Network Security – Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks, intrusion detection. Different Network Security Protocols.[6L] ▪ Operating System Security & Trusted OS-- Memory, time, file, object protection requirements and techniques, Protection in contemporary operating systems, ACLs, DAC, MAC, RBAC, Identification and authentication, Identification goals, Authentication requirements, Human authentication, Machine authentication, OS Forensics. Assurance & Trust, Design principles, Evaluation criteria, Evaluation process.[8L] ▪ Application & Program Security– Flaws, Malicious code: viruses, Trojan horses, worms, Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation o Defenses, Software development controls, Testing techniques.[5L] ▪ Secure Coding. [2L] ▪ Distributed Systems Security. [2L] ▪ Digital Forensics. [2L] ▪ Cyber Laws. [2L]
Text Books, and/or reference material	**Text Books:** 1. The Basics of Information Security by Jason Andress, Syngress Publication. 2. Security in Computing (3rd Edition) 3rd Edition by Charles P. Pfleeger (Author), Shari Lawrence Pfleeger (Author), PHI. 3. B. Tjaden Fundamentals of Secure Computer Systems Franklin Beedle & Associates 2003. 4. D. Russell & G.T. Gangemi, Sr, Computer Security Basics. 5. W. Stallings, Network Security Essentials. Prentice Hall, 2003.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	-	-	1	-	-	-	1
CO2	1	-	3	-	3	-	-	-	-	-	-	-
CO3	2	2	2	2	3	-	-	-	-	-	3	-
CO4	-	2	2	2	3	2	-	1	-	-	-	1
CO5	-	-	-	-	3	3	-	-	-	-	2	1
CO6	2	2	2	2	2	-	-	-	-	-	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="9">Department of Computer Science and Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSO 856</td><td>Optical Network</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Basic Concepts of Computer Networks</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">• CO1: Learn the fundamental concepts of optical networks.
• CO2: Understanding the basic concepts and solution techniques for the different fundamental problems like routing and wavelength assignment</td></tr>
</table>

<table>
<tr><td></td><td>(RWA), virtual topology design, wavelength rerouting, and traffic grooming in optical network design.
• CO3: Acquire knowledge of the wavelength convertible network.
• CO4: Comprehend the basic concepts of multicast routing in optical networks.</td></tr>
<tr><td>Topics Covered</td><td>1. Fundamentals and Optical Components: Optical fiber principles, Optical transmission system, Wavelength Division Multiplexing(WDM), optical networking evolution, Optical Network Architectures; Optical Components- Couplers, Multiplexers and Filters, Optical Amplifiers, Transmitter, Detectors, switches and wavelength converters; Different issues in wavelength routed networks. (12L)
2. Routing and Wavelength Assignment (RWA) algorithms: ILP formulation of the RWA problem, Route Selection algorithms – Fixed Routing, Fixed Alternate Routing, Exhaust Routing, Least Congested Path Routing, Limited alternate Routing. Wavelength Selection algorithms. Joint wavelength-Route selection algorithm. (08L)
3. Wavelength Convertible Networks: Need for Wavelength Converters, Wavelength convertible Switch Architecture, Routing in Convertible Networks, Performance Evaluation of Convertible networks, Network with Sparse Wavelength Conversion, Converter Placement problem. (04L)
4. Wavelength Rerouting Algorithm: Benefits of wavelength rerouting, Issues in wavelength rerouting, Different rerouting algorithms. (05L)
5. Virtual Topology Design: Concept of virtual topology, Limitations on virtual topology, Virtual topology problem formulation, Virtual topology design algorithms. (06L)
6. Traffic Grooming: Basic concepts, Grooming node architecture, ILP formulation of the traffic grooming problem, Different heuristics (MST, MRU, TGCP, etc) for the traffic grooming problem. (05L)
7. Basic concepts of Multicast routing and wavelength assignment. (02L)</td></tr>
<tr><td>Text Books, and/or reference material</td><td>Text Books:
1. WDM OPTICAL NETWORKS Concepts, Design and algorithm by C. Siva Ram Murthy and Mohan Gurusamy (PHI).
2. OPTICAL NETWORKS by Biswanath Mukherjee (TMH).
Reference Books:
1. Optical Networks: A Practical Perspective (3rd Edition) by R. Ramaswami, K. Sivarajan, G. Sasaki (Morgan Kaufmann Publishers).</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1	-	-	-	-	-	-	2
CO2	2	3	3	3	2	-	-	-	-	-	-	3
CO3	2	3	3	2	2	-	-	-	-	-	-	3
CO4	2	3	2	2	1	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO850</td><td>Communication Network</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods
(Continuous (CT), Mid-Term (MT) and End Assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">
• CO1: Identify communication networks suitable for different operational scenarios.
• CO2: Install and troubleshoot typical communication networks.
• CO3: Explain the information flow through various subsystems of a network.
• CO4: Realize the integration between various subsystems of a network.
• CO5: Interpret the current communication technology trends.
• CO6: Evaluate the business potential of future communication networking paradigms.
</td></tr>
<tr><td>Topics Covered</td><td colspan="7">
Module 1: Elements of communication network [2 hrs.]
Network – nodes, links, advantages, evolution path.
Switching – circuit switching, packet switching, store and forward mechanism.
Module 2: Computer networks [8 hrs.]
Computer networks – Ethernet, topology, Ethernet address and IP address.
Interconnecting Ethernets – Hub, Switch, Router.
Layered architectures – Netwrok protocols, TCP/IP, OSI.
Module 3: Landline telephone networks [8 hrs.]
Fundamentals – elements (end nodes, transmission media, switching, signaling), design parameters (GoS, blocking probability, time and call congestion), centralized and distributed switching.
Telephone system – handset, CBS, base unit, transmission impairments, subscriber loop design.
Module 4: Cellular mobile networks [8 hrs.]
Cellular networks – cellular concept, PCS standards (GSM, CDMA), PCS architecture, How a call comes to your mobile phone?
WiFi and Bluetooth.
Module 5: Optical networks [8 hrs.]
FDDI – topology and architecture, access and priority mechanisms, applications.
SONET – topology and architecture, frame format, equipments, deployment and applications.
Under Sea networks – global architecture, how India is served by them?
Module 6: Satellite networks [8 hrs.]
Fundamentals – types of satellites, frequency bands, basic satellite components.
VSAT networks – architecture and applications.
Mobile satellite networks – Iridium, Globalstar.
</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">
Text Book:
1. Communication Networks - J. Walrand.
Reference Books:
1. Telecommunication Switching and Networks - P. Gnanasivam.
2. Optical and Wireless Communications – M. N.O. Sadiku.
</td></tr>
</table>

COURSE ARTICULATION MATRIX

PO CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	2	1	2	1	2	1	1	1	1	1	1
CO#2	3	3	3	1	2	1	1	1	2	1	1	1
CO#3	3	2	3	1	1	1	1	1	1	1	1	1
CO#4	2	2	3	3	2	2	2	1	1	1	1	1
CO#5	1	1	2	2	1	3	2	1	1	2	2	1
CO#6	1	1	2	3	1	3	3	2	1	2	3	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Elective (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO851</td><td>Mobile Computing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous Assessment (CA), Mid-Term (MT), End Term (ET))</td></tr>
<tr><td colspan="3">Data Communication and Computer Networks (ECE618)</td><td colspan="5">CA+ MT + ET [CA: 15%, MT: 25%, ET: 60%]</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Introduce to the basic of Wireless Networks.
CO2: Preparing the right background to take up research works in emerging wireless technologies and Internet of Things.
CO3: To introduce the scopes of using sensing, edge computing, Machine learning mechanisms in pervasive cyber physical systems.
CO4: Able to understand the innovation opportunity in IoT application segments.
CO5: Hands-on experience on Wireless Networks & Mobile Computing.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Physical Layer (6 Hours)
Bit transmission over Wireless, Vary Much different from Wired Network.
Module 2: Mac Layer (8 Hours)
Access in Shared Medium, Difference between Wired MAC & Wireless MAC, Different Type of MACs (a) Random MAC (b) Scheduled MAC, Examples of MAC Implementation (WiFi Protocol --802.11, Bluetooth Protocol--805.15).
Module 3: Network Layer (8 Hours)
Reactive Routing, Proactive Routing, DSR Principle, AODV Principle, Location Aware Routing. Adhoc Network, Delay Tolerant Network, Opportunistic Network Introduction, Architecture & Applications, Routing Algorithms – Epidemic, Prophet, Spray & Wait, Spray & Focus, Maxprop Simulation Tool - ONE Simulator.
Module 4: Transport Layer (8 Hours)
Wireless TCP and rationale, Difference between Wired TCP and Wireless TCP, QoS Measurement of Wireless Networks.
Module 5: Modelling (8 Hours)
Mathematical Modelling of Network Functionalities - Combining them to derived overall performance.
Module 6: Case Study: Implementation of opportunistic Networks in</td></tr>
</table>

	Challenged Network scenarios **(4 hours)** (a) Connection Mechanism (b) Sync - Transferring the information in Collaborative manner (c) Offline Dashboard (Information Summarization) (d)security
Text Books, and/or reference material	**Text Books:** 1. "Mobile Communication", by Jochen Schiller (PEARSON EDUCATION LIMITED). 2. "Wireless Networking" A kumar, D. manjunath, J. Kuri, Elsevier, 2008. 3. "Wireless Communication", T. S. Rappaport, Pearson, latest edition. **Research Papers:** 1. IEEE Infocom Tutorials slides by Prof. Nitin Vaidya. **Others:** Tools: • Sniffer Tool (Wireshark) • Simulation Tools: OMNET, ONE, NS3

COURSE ARTICULATION MATRIX

PO CO	**PO #1**	**PO #2**	**PO #3**	**PO #4**	**PO #5**	**PO #6**	**PO #7**	**PO #8**	**PO #9**	**PO #10**	**PO #11**	**PO #12**
CO#1	3	3	2	1	1	1	1	1	-	2	-	2
CO#2	3	2	2	2	2	1	1	-	-	1	1	2
CO#3	3	2	3	3	3	2	2	1	-	3	3	2
CO#4	3	3	2	1	1	1	1	1	-	2	-	2
CO#5	3	2	2	2	2	1	1	-	-	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Elective (PEL)	Total Number of contact hours = 42				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECO852	MEMS Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and End Assessment (EA))					
Basic Electronics (ECC01), Engineering Mechanics (XEC01)		Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination					
Course Outcomes	After the completion of the course the student will be able to • **CO 1**: Understand characteristics of MEMS system • **CO 2**: Understand fundamental building blocks of general MEMS systems • **CO 3**: Apply qualitative and quantitative analysis techniques in general MEMS systems • **CO 4**: Understand fabrication technology of MEMS system • **CO 5**: Investigate application specific MEMS systems						

Topics Covered	**Module I: Introduction to MEMS & Microsystems Technology [L-1]** History of MEMS technology, Commercial MEMS devices, Application of MEMS devices **Module II: Electromechanical transduction techniques [L-5]** Electrostatic transduction, Electromagnetic transduction, Piezoelectric transduction, Piezoresistive transduction **Module III: Characteristics of MEMS Devices [L-6]** Static characteristics, linearity, nonlinearity, Sensitivity, Resolution, Hysteresis, Dynamic characteristics, Response time, Delay time, Gain, Bandwidth, Quasi static characteristics of MEMS devices. **Module IV: Analysis and Modelling of MEMS devices [L-6]** Concept of Energy, Co-energy, Energy methods, Lagrange equations, Physics based model, Lumped model, Finite element model **Module V: Effect of noise [L-2]** Sources of different types of noise, Thermal noise, Environmental noise, Noise modelling techniques, Statistical methods of noise modelling **Module VI: Integration and packaging [L-6]** Transducers in MEMS, MEMS sensors, MEMS actuators, Integration of MEMS transducers with signal conditioning /driver circuits, Signal amplifiers, Signal filters **Module VII: MEMS device fabrication processes [L-10]** MEMS materials, Bulk micromachining, Silicon anisotropic etching, Surface micromachining, **Module VIII: Scaling effect, Reliability of MEMS devices [L-2]** Effect of inertia in MEMS devices, Scaling effect of MEMS devices, Concept of reliability, Mathematical modelling of reliability, Reliability analysis of MEMS devices. **Module IX: Case studies in MEMS [L-4]** Application specific MEMS devices, MEMS blood pressure sensors, MEMS microphone, MEMS accelerometer, MEMS gyro
Text Books, and/or reference material	**Text Books:** 1. S. D. Senturia, *Microsystem Design*, Springer; 1st edition, 2004 2. K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, G.K. Ananthasuresh, *Micro and Smart Systems*, Wiley India Pvt Ltd, 2010 **Reference books:** 1. Research Articles

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	-	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	3	2	-	-	-	-	-	-	-	-	-	-
CO#4	3	2	-	-	-	-	-	-	-	-	-	-
CO#5	3	1	-	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><th colspan="8">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours = 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECO853</td><td>Electronic System Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous Assessment (CA), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="3">Basic Electronics (ECC01)
Engineering Mechanics (XEC01)</td><td colspan="5">Assignments, Quiz/class test, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After the completion of the course the student will be able to
• CO 1: Understand concept of electronic systems
• CO 2: Understand basic building blocks of electronic systems
• CO 3: Apply quantitative analysis techniques to electronic systems
• CO 4: Learn design techniques of electronic measurement systems
• CO 5: Investigate application specific measurement systems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Introduction to electronic systems [L-1]
Module II: Static and dynamic characteristics [L-6]
Static characteristics of elements, Dynamic characteristics of elements, Quasi-static characteristics of elements, Static characteristics of systems, Dynamic characteristics of systems, linearity, non-linearity, Sensitivity, Resolution, Repeatability, Reproducibility, Response time, Settling time, Gain, bandwidth.
Module III: Electro-Multiphysics Actuation Systems [L-7]
Electro-magnetic actuators, Electro-mechanical actuators, Electro-thermal actuators,
Electro-chemical actuators, Electro-optic actuators, Additional Multiphysics Mechanisms, Electro-Multiphysics drivers.
Module IV: Microcontrollers, Microcomputers and signal processing unit [L-5]
8051, Arduino, Raspberry pi
Module V: Sensors [L-8]
Temperature sensors, Force sensors, Pressure sensors, Vibration sensors, Flow sensors, Motion Sensors, Magnetic flux sensors, Chemical sensors.
Module VI: Signal Conditioning circuits [L-6]
Bridge circuits, Amplifiers, Filters, Oscillators, ADC
Module VII: Data presentation unit [L-3]
Several data presentation devices
Module VIII: Electronic controllers [L-4]
Open loop systems, Closed loop systems, PID controllers
Module IX: Case studies [L-2]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
4. J. Bentley, Principles of measurement systems. Pearson Education India; 3rd edition, 2002
5. W. Bolton, Mechatronics, Fourth Edition, Pearson, 2010
6. Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems: 7th Edition McGraw-Hill; Seventh edition, 2019
7. David A. Bell, Electronic Instrumentation and Measurements, Oxford University Press India; Third edition, 2013
Reference books:
1. Research Articles</td></tr>
</table>

COURSE ARTICULATION MATRIX

PO / CO	PO #1	PO #2	PO #3	PO #4	PO #5	PO #6	PO #7	PO #8	PO #9	PO #10	PO #11	PO #12
CO#1	3	-	-	-	-	2	-	-	-	-	-	-
CO#2	2	3	-	-	-	-	-	-	-	-	-	-
CO#3	1	3	-	-	-	-	-	-	-	-	-	-
CO#4	2	1	2	-	-	2	-	-	-	-	-	-
CO#5	1	1	1	3	-	2	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO850	SOFT COMPUTING TECHNIQUE	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEE 610(NUMERICAL ANALYSIS)		CT+MT+EA					
Course Outcomes	• CO1: For a given non-linear or non-derivative problem, tune the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation. • CO2. Analyze the genetic algorithms, PSO, DE and their applications • CO3: For a given single objective problem (SOP), apply binary coded genetic algorithm (BCGA) and real coded genetic algorithm (RCGA) with different types of crossovers, mutation and also understand the impact of different parent selection strategies. • CO4: For a given multi-objective problem, explain the significance of Difference vector in Differential Evolutionary (DE) technique and also illustrate self-adaptive differential evolutionary (SADE) technique. • CO5: For a given problem, describe fuzzy knowledge base controller (FKBC) showing information and computational flow with membership function, rule base and defuzzification. • CO6: For a given problem, logically clarify the impact of hidden layers in artificial neuron network (ANN) and also stepwise explicate the back propagation algorithm of ANN.						
Topics Covered	Hard Computing and Soft-Computing techniques, Conventional & non-conventional approaches, limitations of hard computing techniques, merits & demerits of soft-computing techniques, practical examples associated with soft-computing techniques. (3) Fundamental concept of optimization techniques and necessity of optimization techniques, types of optimization techniques, coding, fitness/objective function, algorithms. (2) Introduction of Particle Swarm Optimization (PSO) algorithm, Bird flocking & fish schooling, velocity, inertia weight factor, pbest solution, gbest solution, local optima, global optima, Flowchart/algorithm, examples, new modifications of PSO, Parameter Selection in PSO. (6) Introduction of genetic algorithm, Binary coding & decoding, Genetic modelling, Reproduction, Crossover, Mutation, importance of crossover and mutation						

	operators, parent selection strategy, parent selection methods, Flowchart/algorithm, drawback of binary coded genetic algorithm (BCGA), real coded genetic algorithm (RCGA), examples. (6) Fundamentals of Differential Evolution algorithm, difference vector and its significance, Mutation and crossover, comparisons among DE, PSO and GA, Examples, new modifications of DE, Improved DE schemes for noisy optimization problems. (6) Biological neural networks, Model of an artificial neuron, neural network architecture, Characteristics of neural network, learning methods, Taxonomy of neural network architecture, Back propagation networks, architecture of a back propagation network, back propagation learning, Examples, RBF network, Associative memory, Adaptive resonance theory. (7) Fuzzy set theory, Fuzzy systems, crisp sets and fuzzy sets, fuzzy set operations and approximate reasoning, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, examples. (6) Applications of Soft Computing to various fields of engineering. (6)
Text Books, and/or reference material	Text Books: 1. Devendra K. Chaturvedi, "Soft Computing- techniques and its application in electrical engineering", Springer, 2008. 2. Carlos A. Coello,Garry B. Lamont, David A. van Veldhuizen, "Evolutionary Algorithms for solving Multi-objective Problems", Second Edition, Springer, 2007. Reference Books: 1. Jyh-Shing Roger Jang, Chuen-Tsai Sun &EijiMizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall 2. S. Rajasekaran and G. A. VijayalakshmiPai, Neural Networks, Fuzzy Logic and genetic Algorithm Synthesis and Applications, PHI 3. L. A. Zadeh, Fuzzy Sets and Applications, John Wiley & Sons

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	1	1	2	2	2	1
CO2	3	3	3	2	3	1	1	1	2	2	2	1
CO3	3	2	2	1	2	1	1	1	2	3	2	1
CO4	3	2	2	1	2	1	1	1	2	3	2	1
CO5	3	2	2	1	2	1	1	1	2	3	2	1
CO6	3	2	2	2	2	1	1	2	2	3	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEO851	EMBEDDED SYSTEMS AND APPLICATION	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
EEC403 (DIGITAL ELECTRONICS)		CT+MT+EA					

Course Outcomes	• CO1: Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor microcontroller. • CO2: Identify—and exercise—opportunities for hardware and software trade-offs. • CO3: Design of interfacing circuits such as memory, keyboard, display, ADC, DAC, DMA etc. and programming in assembly language for typical microprocessor-based system. • CO4: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application. • CO5: Programming processor specific and processor independent software for different complex embedded system applications.
Topics Covered	Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP, CISC and RISC - Instruction pipelining. General characteristics of embedded system, introduction to different components etc. (3) Basic Microprocessor architectures, organizations and Instruction sets. (4) Memory Classification: ROM, EPROM, EEPROM, RAM. (4) Various types of Interrupts. (2) Programmable Peripheral Devices and Interfacing 8255, 8259, 8257, 8251, 8253, ADC, DAC and Practical Applications. (4) Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of Architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports. (3) Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. (4) ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc. (6) Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events -Memory Management, Interrupt Routines. (6) Applications of Embedded systems in different field of engineering. (6)
Text Books, and/or reference material	Text Books: 1. The 8085 Microprocessor: Author: Ramesh Gaonkar, Pub: PRI 2. The 8051 Microcontroller and Embedded System: Author: Muhammad Ali Mazidi & J. G. Mazidi. 3. Advanced Microprocessors and Interfacing: Author: Badri Ram, Tata McGraw-Hill Publishing Co. Ltd. Embedded Systems Architecture, Programming and Design, Ral Kamal TMH, 2008. Reference Books: 1. Embedded Systems Design, Heath Steve, Second Edition-2003, Newnes, 2. Computers as Components; Principles of Embedded Computing System Design, Wayne Wolf Harcourt India, Morgan Kaufman Publishers, First Indian Reprint. 2001. 3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1		2	1	3	1	1	1	

CO2	3	1	2	1	1			1				1
CO3	3	3	3	3	3	1	1	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1
CO5	3	3	3	1								1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EEO852</td><td colspan="2">MICRO-ELECTROMECHANICAL SYSTEM</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">• CO1: Understanding the fundamentals of MEMS technology and its applications
• CO2: To study and learn the different aspects of Microfabrication Procedures.
• CO3: To learn about the Microfabrication Procedures.
• CO4: To study about the Microsensors and Micro actuators and their application.
• CO5: Learn about the RF-MEMS and Bio-MEMS techniques and applications.
• CO6: To learn the modelling and computer simulation techniques for MEMS designs.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Introduction to MEMS: Introduction to MEMS technology, Why MEMS, Advantages, Applications, examples of MEMS devices, MEMS in Electronic Industries, VLSI Technology for fabrication of integrated circuits chips. (3)
Fundamentals of Microfabrication Procedures: Introduction to Thin Film Technology, Clean rooms, Surface Micromachining, MEMS fabrications process flow (Deposition, Lithography and Etching), MEMS fabrication instruments, MEMS fabrication bench, Micromachining, Surface Modelling. (3)
Thin Film Deposition Techniques: Substrate Materials, Silicon Wafer, Metal Polymer, Plastic substrate, Thin Film Deposition Process, Physical Deposition process, Chemical Vapour Deposition, Sputtering, Electrodeposition, Electroplating, and Oxidation. (5).
Fundamentals of Lithography: Introduction to Thin Film Technology, Different Lithography Technique, Mask and Mask Material, Photoresists, Positive Photoresists, Negative Photoresists, Lift-off, LIGA. (5)
Etching Procedures: Need for etching process, different etching techniques, wet etching, dry etching, etching materials, Chemical Etching, Plasma Etching, precautions. (5)
Micro sensors and Micro actuators: Accelerometers, Gyroscopes, Angle-Sensors, Pressure Sensor, Microphones and MEMS sensors. (3)
Introduction to BioMEMS: MEMS technology in biomedical applications, Microelectrodes for Biomedical Engineering, Introduction to Microfluidics and its Applications. (4)
RF MEMS: MEMS for telecommunications (RF MEMS), RF MEMS Components, RFMEMS applications, Recent RF MEMS development, RF</td></tr>
</table>

	MEMS Limitations, RF MEMS Challenges. (3) Computational Modeling of MEMS and MEMS Devices: Overview of MEMS-CAD software; followed by tour of MEMS Design Centre, COMSOL, IntelliSuite. (4) Recent Development in Micro technology: Introduction to Nanotechnology, Carbon Nanotube, Graphene, CNT Sensors Graphene Sensors. (3)
Text Books, and/or reference material	Text Books: 1. An Introduction to Microelectromechanical Systems Engineering: Nadim Maluf, Artech House, 2000 2. Microsystem Technology: Wolfgang Menz, Jürgen Mohr, Oliver Paul, John Wiley & Sons, 2008. Reference Books: 1. An Introduction to Microelectromechanical Systems Engineering: Nadim Maluf, Kirt Williams, Artech House, 2004. 2. Fundamentals of Microfabrication: The Science of Miniaturization, Marc J. Madou, CRC Press; 2nd Ed. 2002. 3. MEMS: A Practical Guide to Design, Analysis, and Applications: Jan Korvink Oliver Paul, William Andrew; 1 edition (November 14, 2005

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	1	1	1	1	1	1
CO2	3	3	3	3	3	1	2	2	2	1	2	1
CO3	3	3	3	3	3	1	2	2	2	1	2	1
CO4	3	3	3	3	3	2	2	2	2	1	2	2
CO5	3	3	3	2	3	1	2	2	2	1	2	2
CO6	2	2	3	2	3	1	1	1	3	0	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEO 851	**Tribology**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: To learn the basic knowledge of surface topography and contact between engineering surfaces. CO2: To learn the basic theory and application of friction and wear for different materials CO3: To learn about lubricants and lubrication for different bearings CO4: Introduced to Bio-tribology of human joints CO5: Introduced to Micro-tribology for MEMS applications						
Topics Covered	**Part I - Basic Tribology** **Surface topography:** Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. 2 **Contact between surfaces:** Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces.						

	4 **Friction and Wear of contact surfaces:** Laws and Theories of friction and wear; Friction and Wear of different materials; Application to friction materials. 8 **Lubricants and lubrication:** Viscosity of lubricants; Composition and properties of oils and greases; Reynolds equation; Type of lubrications - Hydrostatic lubrication, Hydrodynamic lubrication; Elastohydrodynamic lubrication; Boundary lubrication, and application to bearings. 14 **Part II - Advanced Tribology** **Microtribology:** Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Applications to MEMS. 6 **Biotribology:** Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication: Mechanism of articular cartilage damage; Artificial joint replacements; Skin Tribology 8)
Text Books, and/or reference material	**Text Books:** 1. Engineering Tribology - Dr. Prasanta Sahoo 2. Introduction to Tribology of Bearings-- B.C.Majumder 3. Principles of Tribology-- J.Halling 4. Basic Lubrication Theory - Alastair Cameron

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO851	Leadership and Corporate Strategy	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
nil		CT+MT+EA					
Course Outcomes	• CO1: Understanding the nature of leadership within human Behaviou • CO2: Understanding ethics and human values • CO3: Understanding the correlation of work –rewards- stress.						
Topics Covered	Introduction: The nature of Leadership; the nature of Managerial work, Effective Leadership Behaviour; Participative Leadership [4] Dyadic Role Making; Power and Influence; Managerial Traits and Skills [4] Charismatic and Transformational Leadership [2] Leadership in terms and Decision groups; Strategic Leadership by Executives [3] Developing Leadership Skills; Ethical Leadership and Diversity [2] Issues about research methods in leadership [1] Entrepreneurship: Introduction; Advantages of entrepreneurship; TE Analysis; Pitfalls of Entrepreneurship, difference between a entrepreneur and leader; qualities of an entrepreneur [4] Strategic Management Process: Vision, Mission, SWOT Analysis; Defining goals and objectives; key success factors for management. [6] Pricing Policy; Process of budget [2] Advertisement: Role and methods, the seven tests and pricing [1] Marketing: 4 P's of marketing Mix; Balance Scorecard [2].						

Text Books, and/or reference material	Suggested Text Books: 1. GARY YUKL. Leadership in Organizations ; Pearson Education, 2008 2. Thomas .W Zimmereer and Norman M. Scarborough. Essentials of Entrepreneurship and Small Business Management; Pearson Education; 2007. Suggested Reference Books: 1. Debasis Chatterjee; "Light the fire in your Heart "; Full Circle Pub. House.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	3	3	3	1	1	1	1	1	1	1	1
CO2	-	3	3	3	1	1	1	1	1	1	1	1
CO3	-	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Annexure - II

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

ACADEMIC CALENDAR - 2022-2023 (REVISED)

	ODD SEMESTER										EVEN SEMESTER											
DAYS	AUG' 22		SEPT' 22		OCT' 22		NOV' 22		DEC' 22		JAN' 23		FEB' 23		MARCH' 23		APRIL' 23		MAY' 23		JUNE' 23	
SUN											1											
MON	1	CLASS BEGINS									2	CLASS BEGINS							1			
TUE	2						1				3								2			
WED	3						2				4		1		1	CLASS BEGINS (UG-2nd Sem)			3			
THU	4		1				3		1		5		2		2				4		1	END-TERM EXAM (THEORY) (UG-2nd Sem)
FRI	5		2				4		2		6		3		3				5	Buddha Purnima	2	
SAT	6		3		1		5		3		7		4		4		1		6		3	
SUN	7		4		2	Gandhi Birthday	6		4		8		5		5		2		7		4	
MON	8	Supp. Exam, Even Sem. 2021-22	5		3	Mahaasthami	7		5		9	Supp. Examination, Odd Sem 2022-23 (Except First Year UG)	6		6		3		8		5	
TUE	9	Muharram	6		4		8	Guru Nanak's Birthday	6		10		7		7		4		9		6	
WED	10	Supp. Exam, Even Sem. 2021-22	7		5	Dussehrra	9		7		11		8		8	Holi / Dolyatra	5		10		7	
THU	11		8		6		10		8		12		9		9		6		11		8	
FRI	12		9		7		11		9		13		10		10		7	Good Friday	12		9	
SAT	13		10		8		12		10		14		11		11		8		13		10	
SUN	14		11		9	Id-e-Milad	13		11		15		12		12		9		14		11	
MON	15	Independence Day	12		10		14	CLASS BEGINS (UG-1st Sem)	12		16		13		13		10	MID-TERM EXAM (THEORY) (UG-2nd Sem)	15		12	
TUE	16		13		11		15		13		17		14		14		11		16		13	
WED	17		14		12		16		14		18		15		15		12		17		14	
THU	18		15		13		17		15		19		16		16		13		18		15	
FRI	19	Janmasthami	16		14		18		16		20		17		17		14		19		16	
SAT	20		17		15		19		17		21		18		18		15		20		17	
SUN	21		18		16		20		18		22		19		19		16		21		18	
MON	22		19		17		21	END-TERM EXAM (THEORY) (Except First Year UG)	19	* MARKS SUBMISSION	23		20	MID-TERM EXAM (THEORY) (Except First Year UG) + END-TERM EXAM (THEORY) (UG-1st Sem)	20	* MARKS SUBMISSION (UG-1st Sem)	17		22	# MARKS SUBMISSION	19 19	
TUE	23		20		18		22		20	MID-TERM EXAM (THEORY) (UG-1st Sem)	24		21		21		18		23		20	
WED	24		21		19		23		21		25		22		22		19		24		21	
THU	25		22		20		24		22		26	Republic Day	23		23		20		25		22	# MARKS SUBMISSION (UG-2nd Sem)
FRI	26		23		21		25		23		27		24		24		21		26		23	
SAT	27		24		22		26		24		28		25		25		22	Idul-Fitr	27		24	
SUN	28		25		23		27		25	Chirstmas Day	29		26		26		23		28		25	
MON	29		26	MID-TERM EXAM (THEORY) (Except First Year UG)	24	Diwali	28		26		30		27		27		24	END-TERM EXAM (THEORY) (Except First Year UG) + Supp. Exam. UG-1st Sem	29		26	
TUE	30	Pub. of Supp. Result, Even Sem, 2021-22	27		25		29		27	Pub. of Result, Odd Sem, 2022-23	31	Pub. of Supp. Result, Odd Sem, 2022-23	28		28	Pub. of Result, UG-1st Sem, 2022-23	25		30	Pub. of Result, Even Sem, 2022-23	27	Pub. of Result, 2nd Sem - UG, 2022-23
WED	31		28		26		30		28						29		26		31		28	
THU			29		27				29						30		27				29	Id-ul-zoha
FRI			30		28				30						31		28				30	
SAT					29				31								29					
SUN					30												30					
MON					31																	

Festival Break (Students, Faculty): October 04 - 07, 2022

Winter Break (Students): December 01 - 31, 2022

For 1st Sem-UG: December 25-31, 2022

Winter Break (Faculty): December 20 - 30, 2022

Summer Break (Students): May 01 - July 16, 2023

For 2nd Sem UG: June 08 - July 16, 2023

Summer Break (Faculty): June 05 - July 07, 2023

* Last date of Odd Semester Marks submission by the teachers in Chanakya Software

Last date of Even Semester Marks submission by the teachers in Chanakya Software

Academic Year 2023-24 begins : July 17, 2023

Date: 28/07/2022

Dean (Academic Courses)

Registrar

Annexure - III

JH (A&E)
Next UGAC Agenda
point under
any other matter.

To

Dr. Subhrabrata Choudhury

Associate Professor

CSE Department, NIT Durgapur

Subject: Request for re-evaluation of marks in Internet of Things (CSE 814)

Dear Sir,

With due respect, I beg to state that I expect a better grade in the subject, Internet of Things (CSE 814), in the 8th semester, of the B.Tech. CSE course. Along with the marks in the continuous assessments which were declared (which I have gone through) previously and my performance in the end semester examination are not matching with my expectation and thereby I want to reassure. 'X'

I, therefore, request you to kindly review and re-evaluate my answer script and take necessary actions at your end, to correct the marks recorded on my 8th semester grade card.

Thanking You,

Yours sincerely,

Soumik Samanta

Soumik Samanta

Roll No: 18CS8127

Ph No: 8013918694

Email: soumiksamantaa@gmail.com

Considering the appeal made in 'X' above I went through the declared marks in CA's and Online part (30 marks) of the end semester. I also checked the end sem script. I agree that there were mistakes' in mark entries in the Chanakya portal from my end. I request the concerned authority to consider it as human error and make following changes. I apologyse for the delay in my response but request the concerned authorities to make necessary changes in the final marksheet. The request for the correction are sent and attached herewith in proper format. However, I mention them below again for more clarity.

Subject Code	Roll no.	OLD Marks			New Marks			Justification	Name of Examiner
		CA	MT	ET	CA	MT	ET		
		15	17	40	15	20	55	Mistake in Data Entry	Subhrabrata Chowdhury

SChowdhury
24/08/22

Dear (ACAD) I request the to consider the case and correct the mistake.

(HOD, CSE) 24/08/22

Head
Computer Science & Engineering Department
National Institute of Technology
Durgapur-713209, W.B., India

Form: NITD/ACA-07

NATIONAL INSTITUTE OF TECHNOLOGY, DURGAPUR

MAHATMA GANDHI AVENUE

DURGAPUR 713 209, WEST BENGAL, INDIA

Website: www.nitdgp.ac.in

ACADEMIC SECTION

Request for Change of Grade

Programme: BTECH/ ~~MTECH / MBA / MSC / MSW~~ Semester: EVEN Session: 2021 - 2022

Department of Computer Science & Engineering

Sl. No.	Subject Code	Roll No.	Old Marks			New Marks			Justification	Name of the Examiner
			CA	MT	ET	CA	MT	ET		
	CSE 214	18CS8127	15	17	40	15	20	55	mistake in data entry	Subhrabrata Choudhury

Certified that the DAC has examined the requests of the teachers to revise the marks, and is satisfied that the new marks proposed are justified. Revision of marks is recommended.

Date: 24/08/2022

Head of the Department

Head
Computer Science & Engineering Department
National Institute of Technology
Durgapur-713209, W.B., India

*Please note that this form in consolidated manner is to be forwarded by the HOD / HOS only to academicsectionug@admin.nitdgp.ac.in (copy to sirshendu.mondal@me.nitdgp.ac.in) by August 4, 2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Academic Section

ANNEXURE 67.5.1

Date: 08.06.2022

Minutes of the meeting of Research Academic Committee (RAC) held on 08.06.2022 (Wednesday) at 03.00 pm.

The Chairman welcomed the members to the meeting and the agenda was placed for discussion.

Item # 1 **Confirmation of the minutes of the meeting of RAC held on 12.04.2022.**

The minutes of the RAC meeting held on 12.04.2022 were confirmed.

Item # 2 **To consider the result of the examinations for course work subjects in even semester 2021-2022.**

The provisional results of 113 students are recommended for approval and subsequent publication on public domain.

Item # 3 **To consider the academic calendar 2022-2023.**

The academic calendar 2022-2023 of the PG program will be followed with the following modifications.

- Results will be declared after 10 working days of the publication of results of PG program.
- Research Methodology classes will be taken up separately and not with the PG program.

Item # 4 **To consider the matter for uploading PhD theses to on INFLIBNET platform in light of the decision taken by the Senate.**

The matter is discussed in detail and the following resolutions are taken for approval.

- Meta Data of the theses from 2018 onwards will be uploaded in PDF format.
- From April 2018 (13th Convocation) to June 2022 full theses will be uploaded.
- From July 2022 onwards theses arranged chapter wise will be uploaded.
- The theses will be uploaded by the INFLIBNET Coordinator of the Institute. The Supervisor concerned will send the theses to the INFLIBNET Coordinator.
- A declaration / consent will be obtained from the individual scholar as -

  ".... I am the sole owner of copyright on this thesis. The National Institute of Technology, Durgapur is hereby granted, non - exclusive, royalty- free and non - transferable rights to make available, in full or in part without any modifications, this thesis in electronic/ printed form for public use at no charge. Any use of material from this thesis/ dissertation must be accompanied with appropriate citation.

  I wish to allow open access to my thesis."
- The department of CSE will extend its manpower support to the INFLIBNET Coordinator.

Item # 5 **To consider the matter of advertisement for admission in odd semester to PhD progamme 2022-2023.**

The format of the advertisement was circulated / published.

It is also resolved that

- Advertisement of category J will not be published.
- Attendance of all the PhD scholars (regular and professional) will be registered at the department level.

Item # 6 **To consider the summarized list of documents to be submitted during different phases after admission to award of PhD degree.**

The format of the advertisement was circulated / published.

Item # 7 **To consider registration for Ph.D. Programme**

SL. NO	ROLL NO.	NAME	DEPT	COURSE WORK (TOTAL CREDIT)			NAME OF THE SUPERVISOR(S)	DATE OF REG.
				ASGN. BY DSC	AS PER REGULATION	COMPLETED		
1	20MA1501	Biswajit Some	MA	20	20	20	Dr. A. Pal	06.04.2022
2	20PH1502	Bilwadal Dutta	PH	19	16	19	Dr. A. K. Meikap	19.04.2022
3	20CH1103	Ravindra Kumar	CH	12	12	12	Dr. A. K. Sadhukhan Dr. B. Ruj CMERI Durgapur	10.05.2022
4	20MA1106	Subhadip Pal	MA	20	20	20	Dr. L. K. Dey	11.05.2022
5	20MA1104	Haradhan Ghosh	MA	20	20	20	Dr. S. Bagchi	11.05.2022
6	20MA1101	Deep Mukhopadhyay	MA	20	20	20	Dr. S. Bagchi	11.05.2022
7	20MA1105	Ankan Shaw	MA	20	20	20	Dr. S. Bagchi	11.05.2022
8	19MM1102	Raj Kumar Kalshyan	MM	12	12	12	Dr. S. Ghorai Dr. G. MD. Chowdhury, RDCIS, Ranchi	24.05.2022
9	20MM1105	Sagar Das	MM	8	8	12	Dr. S. Bera Dr. B. K. Show	24.05.2022
10	19MM1501	Akhtarujjaman Sarkar	MM	8	8	12	Dr. S. Bera. Dr. S. Chabri, Narula Institute of Technology, Kolkata	24.05.2022

The registration to the PhD programme of the above mentioned scholars are recommended for approval on the dates as mentioned against the respective scholars.

Item # 8 **To consider the name of the students to be awarded with Ph.D. Degree** –completed all requirements for the award of Ph.D. Degree.

SL. NO	REGN. NO	DEPT.	NAME OF THE SCHOLAR	TITLE OF THE THESIS	NAME OF THE SUPERVISOR(S)	DATE OF AWARD
1	NITD/PhD/MA /2016/00710	MA	Sanghamitra Dey	Some fuzzy inference techniques and their applications to different fields	Dr. G. Panigrahi Dr. D. K. Jana, HIT, Haldia	31.01.2022

					Dr. M. Maiti Vidyasagar University	
2	NITD/PhD/ECE/2013/00406	EC	Arghya Guchhait	Communication and RADAR Technology Convergence for Intelligent Transportation System	Dr. B. Maji Dr.D.Kandar NEHU Shillong	23.03.2022
3	NITD/PhD/ECE/2013/00404	EC	Mrinmoy Sarkar	Study of Different Performance Enhancement Technique in Communication System Exploring New Dimensions	Dr. B. Maji Dr. A. Kumar Vidyasagar University	30.03.2022
4	NITD/PhD/CS/2018/01038	CS	Sumana De	Knowledge Management Systems for Problem Detection and Diagnosis	Dr. B. Chakraborty	04.04.2022
5	NITD/PhD/ECE/2016/00831	EC	Subhankar Shome	Phased MIMO Radar in Hostile Environment	Dr. B. Maji Dr. R. N, Bera, SMIT Sikkim	06.04.2022
6	NITD/PhD/CE/2018/01005	CE	Subhrasmita Majumder	Structural Behaviour of RC Beams and Beam-Column Joints Strengthened with Geosynthetic Material	Dr. S. Saha	13.04.2022
7	NITD/PhD/ME/2018/01027	ME	Ananda Rabi Dhar	Development of Metaheuristic Algorithms tuned Artificial Intelligence-based Models for Prediction and Optimization of Process Parameters of Metal Additive Manufacturing	Dr. S. S. Roy Dr. N. Mandal, CMERI Durgapur	16.04.2022
8	NITD/PhD/MT/2015/00686	MM	Krishnan Bandyopadhyay	Molecular Dynamics and Finite Element Method based Modelling and Simulations of Nanoparticles and Nanocomposites for Advanced Structural Applications	Dr. M. M. Ghosh Dr. K. S. Ghosh	19.04.2022
9	NITD/PhD/BT/2017/00972	BT	Atrayee Sarkar	RNAi-mediated Resistance to Rice Blast Fungus: Transformative and Non-Transformative Approaches	Dr. S. Roy Barman	20.04.2022
10	NITD/PhD/MM	MM	Prosanta Biswas	Development and	Dr. M. K. Mondal	29.04.2022

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	E/2017/00856			micromechanics of in-situ $Al\text{-}Mg_2Si$ Composites	Dr. D. Mandal	
11	NITD/PhD/MA /2018/01082	MA	Palash Sahoo	Some Real Life Decision Making Problems in Different Imprecise Environment	Dr. G. Panigrahi Dr. D. K. Jana HIT Haldia	29.04.2022
12	NITD/PhD/ME /2016/00779	ME	Pabitra K. Mandal	Experimental and Numerical Investigation on Optimum Orientation of Fin Arrayed Heat Sinks	Dr. S. C. Rana Dr. D. Bhanja NIT Silchar	06.05.2022
13	19RCY011	CY	Tithli Sadhu	Improvement of Nutritional Quality of Fish during Conventional Frying Process: A Novel Approach Using Artificial Intelligence	Dr. J. Chakrabarty Dr. A.Bhattacharjee	10.05.2022
14	NITD/PhD/HSS /2016/00721	HS	Anita Nandi	Risk Assessment and Corporate Profiling: An Empirical Study of Selected Sectors in India	Dr. P. P. Sengupta Dr. A. Dutta Sikkim University	16.05.2022
15	19RHS025	HS	Sarmistha Bhaumik	Women Empowerment and Development through Women Run Police Stations in West Bengal	Dr. P. P. Sengupta Dr. P. K. Ghosh ViswaBharati.	19.05.2022
16	NITD/PhD/CS/ 2018/01021	CS	Mahabub Hasan Mahalat	Design and Analysis of Light Weight Physically Unclonable Function (PUF) Trageting Cost Effective Hardware Security	Dr. Bibhash Sen	25.05.2022
17	20RCE002	CE	Biplab Behera	Seismic Performance of Masonry Structure with Geogrid Reinforcement	Dr. R. P. Nanda	30.05.2022
18	NITD/PhD/EC/ 2018/01052	EC	Chiradeep Mukherjee	Implementation of Irreversible and Reversible Circuits using Layered T Methodology to Design High Performance Digital Logic Circuits Based on Quantum Cellular Automata (QCA)	Dr. B. Maji Dr. S. Panda, DSCSITSC, Kolkata Dr. A. K. Mukhopadhyay, Bundelkhand University, Jhansi	30.05.2022

The award of the PhD degree to the above mentioned scholars are noted on the dates as mentioned against the respective scholar, to be reported to the Senate for recommendation.

Item # 9 To consider the appeal for an extension of period of registration of the following scholars

- Padma Seragadam (Roll No. 16/CHE/1505, Reg. No. NITD/PhD/CHE/2017/00907 dt. 11.05.2017)-Extension for 1 year from 11.05.2022 (1^{st}).
- Saurabh Pal (Roll No. 15/CA/1501, Reg. No. NITD/PhD/CS/2017/00891 dt. 02.05.2017-Extension for 1 year from 02.05.2022 (1^{st}).
- Himangshu Pal (Roll No. 14/ECE/1514, Reg. No. NITD/PhD/EC/2016/00745 dt. 19.04.2016)-extension for 1 year from 19.04.2022 (2^{nd}).
- Avick Kumar Dey (Roll No. 14/CA/1503, Reg. No. NITD/PhD/CA/2016/00749 dt. 02/05/2016)-extension for 1 year from 02.05.2022 (2^{nd})

- RangaballavPradhan (Roll No. 15/CSE/1105, Reg. No. NITD/PhD/CS/2017/00882 dt.27.04.2017)- extension for 1 year from 27.04.2022 (1st).
- Pradipta Banerjee (Roll No. 15/IT/1109, Reg. No. NITD/PhD/CS/2017/00888 dt. 28.04.2017)- extension for 1 year from 28.04.2022 (1st)
- Pratik Kumar Sinha (Roll No. 15/IT/1108, Reg. No. NITD/PhD/CS/2017/00889 dt. 28.04.2017)- extension for 1 year from 28.04.2022 (1st)
- Sanjeet Kumar (Roll No. 15/CA/1502, Reg. No. NITD/PhD/CS/2017/00913 dt. 16.05.2017)- extension for 1 year from 16.05.2022 (1st)
- Kingsuk Majumdar (Roll No. 15/EE/1502, Reg. No. NITD/PhD/EE/2016/00781 dt. 19.09.2016)- extension for 1 year from 19.09.2022 (2nd)
- Sanjib Biswas (Roll No. 16/MS/1302, Reg. No. NITD/PhD/MS/2017/00914 dt. 17.05.2017) extension for 1 year from 17.05.2022 (1st)
- Payel Mondal (Roll No. 16CH1102, NITD/PhD/CH/2017/00924 dt. 24.07.2017) extension for 1 year from 24.07.2022 (1st)
- Vinay Ravindra Varude (Roll No. 16ME1303, NITD/PhD/ME/2017/00866 dt. 07.02.2017) extension for 1 year from 07.02.2022 (1st)
- Subhajit Roy (Roll No. 16CS1303, Reg. No. NITD/PhD/CS/2017/00904 dt. 05.05.2017)- extension for 09 (nine) months from 05.05.2022 (1st)
- Prakash Mondal (Roll No. 15/CE/1502, NITD/PhD/CE/2017/00886dt. 28.04.2017) extension for 1 year from 28.04.2017 (1st)
- Deepa Naik (Roll No. 12/CSE/1103, Reg. No. NITD/PhD/CS/2015/00672 dt. 20.11.2015) extension for 6 months from 20.05.2022 (2nd)
- Biswaranjan Mishra (Roll No. 14/EE/1103, Reg. No. NITD/PhD/EE/2015/00661 dt. 17.11.2015) extension for 2 years from 17.11.2020 (1st) – special consideration of two (02) years.

The matter is recommended for approval as the formalities in this regard are fulfilled. Further it is recommended for approval by the Senate for relaxation of one year extension for period of registration also for academic year 2022-2023 on specific recommendation of the respective DSC due to COVID19 situation.

The matter of Biswaranjan Mishra (Roll No. 14/EE/1103, Reg. No. NITD/PhD/EE/2015/00661 dt.17.11.2015) is referred to the Senate.

Item # 10 **To consider the appeal for discontinuation from PhD Program**

- **Jyotirmoy Halder (Roll No. 20CY1103) – Family issue.**
- **Syed Wasim Parvez (Roll No. 14/BT/ 1108)- Health issue**

The above matter has been discussed and as recommended by DSC of the student it may be forwarded to the Chairman, Senate for his approval.
The matter of release of regular Institute fellows will be guided by the regulations of the programme while the release of other regular fellows will be guided by the regulations of the respective funding agencies.

Item # 11 **To consider the matter regarding the approval for extension of period for delivering preregistration seminar:**

- **Santanu Dutta (18MS1505)- (Date of Admission: 31.07.2018)**
- **Somashish Saha (19CH1502)(Date of Admission: 27.07.2019)**

The matter related to Santanu Dutta (18MS1505) (extension up to Dec. 2022) and Somashish Saha (19CH1502)(extension up to Dec. 2022) are recommended for approval.

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Item # 12 **To consider the matter regarding the approval for Campus release of –**

- **Shubhrajyoti Kundu (Reg. No.- 20REE011) - Appointed in K. K. Group of Institutions, Dhanbad on 25.05.2022.**
- **Ashis Bera(Reg. No.- 19RMA031)- Appointed in VIT, Chennai on 02.05.2022**

The matter is approved subject to submission of the NOC from the employer.

The scholarship will be stopped from the date of intimation regarding employment,

Item # 13 **To consider the matter regarding the approval of reconstitution of DSC:**

- Saurabh Pal (15/CA/1501)- Inclusion of Dr.Gautam Bandyopadhyay (MS) in place of Dr.Sajal Mukhopadhyay (CS) – revised DSC
- Amit Kumar Banerjee (19HS1503)- Inclusion of Co-Supervisor Dr.Partha PratimSengupta (HS).
- Saroj Khutia (17PH1105)- Inclusion of Dr. R. N. Saha (CY) in place of Dr. S. Ghosh (EE, Retired.).
- Madhab Dhali (17EC1101)- Inclusion of Co-Supervisor Dr.Rajib Kar (EC)
- Sanjeet Kumar (15/CA/1502)- Inclusion of Dr. Sanjay Dhar Roy (EC) in place of Dr.Tanmay De (CS) – revised DSC

The matter is recommended for approval.

Item # 14 **To consider the matter regarding the appeal on pre-submission seminar of Partha Parichha (Roll. No. 16/MA/1504, Reg. No. NITD/PhD/MA/2016/00827).**

The matter is discussed and Partha Parichha (Roll. No. 16/MA/1504, Reg. No. NITD/PhD/MA/2016/00827) may be allowed to appear for a pre submission seminar on fulfilment of the formalities for the same.

The meeting ended with vote of thanks to the Chairman.

R Kumar Barkar 30/06/2022
Dean (Academic Research)
Date: 30.06.2022.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

OFFICE OF THE DEAN (ACADEMIC RESEARCH)

PROVISIONAL RESULT OF PHD COURSE WORK (EVEN SEMESTER/ SESSION: 2021-2022)

Sl No.	Dept./ Centre	Name of the Scholar	Roll No.	Course / Sub. Code-1	Grade	Course/ Sub. Code-2	Grade	Course / Sub. Code-3	Grade	Course / Sub. Code-4	Grade	Remarks
1	BT	DEBARPITA DUTTA	21BT1101	XE9031	A	BT2001	C	BT9054	B			QUALIFIED
2	BT	MAITHILI ADHIKARY	21BT1102	XE9031	A							QUALIFIED
3	BT	PINKAN SADHUKHAN	21BT1103	XE9031	B	BT2001	C	BT9031	B			QUALIFIED
4	BT	SHARAD GHOSH	21BT1104	XE9031	A	BT9032	C	BT9045	B			QUALIFIED
5	BT	SOURAV PAUL	21BT1105	XE9031	A							QUALIFIED
6	CE	AMGOTH RAJENDER	21CE1101	XE9031	A	MA2002	B	CE9034	C			QUALIFIED
7	CE	APURBA PAL	21CE1102	XE9031	A							QUALIFIED
8	CE	MD MOZAFFAR MASUD	21CE1103	XE9031	A	CE9034	A	CE9051	B	CE9095	A	QUALIFIED
9	CE	NISHEETH SHEKHAR	21CE1104	XE9031	A	CE9084	B					QUALIFIED
10	CE	SUKAMAL KANTA GHOSH	21CE1105	XE9031	A	CE9034	B					QUALIFIED
11	CE	NEETIKA SAHA	21CE1106	XE9031	A							QUALIFIED
12	CE	KAPILDEO PRASAD YADAV	21CEQ1106	XE9031	A	MA2002	A	MT2001	A			QUALIFIED
13	CH	ARNAB SAU	21CH1101	XE9031	A	ES9021	B					QUALIFIED
14	CH	NABANITA GHOSH	21CH1102	XE9031	A	CH2001	A					QUALIFIED
15	CH	SAHELI KAR	21CH1103	XE9031	A	CH2001	B					QUALIFIED
16	CH	PRATYUSH KUMAR PAL	21CH1502	XE9031	B	CH2011	B	CH9015	A			QUALIFIED
17	CH	SAMPURNA SANTRA	21CH1503	XE9031	A	CH9011	C	CH9014	C			QUALIFIED
18	CH	SHEFALI MAMATAJ	21CH1504	XE9031	A	CH9011	C	CH9014	C			QUALIFIED
19	CH	SUMIT MAHTO	21CH1505	XE9031	A	CH9011	C	CH9014	C			QUALIFIED
20	CH	NANOTTAM BEHERA	20CH1504	XE9031	A	CH2011	C	CH9015	B			QUALIFIED
21	CS	ARNAB CHATTERJEE	21CS1101	XE9031	B	PH2103	A					QUALIFIED
22	CS	BISWAJIT PATRA	21CS1102	XE9031	A	CS9037	EX	CS9045	A			QUALIFIED
23	CS	KHITISH KUMAR GADNAYAK	21CS1104	XE9031	A	CS9031	B	CS9045	A			QUALIFIED
24	CS	SOM BANERJEE	21CS1105	XE9031	A							QUALIFIED
25	CS	SUMAN NANDI	21CS1106	XE9031	A							QUALIFIED
26	CS	SUMANA NASKAR	21CS1107	XE9031	A	CS9045	B					QUALIFIED
27	CS	SUBASHIS KARMAKAR	21CS1108	XE9031	B							QUALIFIED

Dean (Academic Research)
Date: 08-06-2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
OFFICE OF THE DEAN (ACADEMIC RESEARCH)
PROVISIONAL RESULT OF PHD COURSE WORK (EVEN SEMESTER/ SESSION: 2021-2022)

28	CS	DURGESH LOHAR	21CS1109	XE9031	A	CS9071	B					QUALIFIED
29	CS	SHWETA PATEL	21CS1110			CS9045	A					QUALIFIED
30	CS	RAJESH MUKHERJEE	21CS1111			CS9093	A	CS9030	B	CS9037	B	QUALIFIED
31	CS	ARUNITA DAS	21CS1501	XE9031	A							QUALIFIED
32	CS	POULOMI MUKHERJEE	20CS1105			CS9021	B	CS9027	B			QUALIFIED
33	CS	KAZI AMRIN KABIR	20CS1108	XE9031	A	CS9045	B					QUALIFIED
34	CS	SANDIP CHAKRABARTY	20CS1503			CS9037	A					QUALIFIED
35	CY	RAKHI SENAPATI	21CY1102	XE9031	A	CY4103	A	CY4101	B			QUALIFIED
36	CY	BIJOY RAJAK	21CY1103	XE9031	EX							QUALIFIED
37	CY	SAYON SATPATI	21CY1104	XE9031	A	CY4103	A					QUALIFIED
38	CY	PRADEEP KUMAR ROUT	21CY1501	XE9031	A	CY4103	A					QUALIFIED
39	EC	KRITTIKA MUKHERJEA	21EC1101	XE9031	B							QUALIFIED
40	EC	SATISH KUMAR	21EC1103	XE9031	A							QUALIFIED
41	EC	SAYANI BINDAI	21EC1104	XE9031	A	EC2011	B					QUALIFIED
42	EC	MD SUJAUDDIN AHMMED	21EC1502	XE9031	A	EC9039	A					QUALIFIED
43	EC	ANANYA BANERJEE	21EC1503	XE9031	A							QUALIFIED
44	EC	DEBASMITA MANNA	21EC1504	XE9031	A							QUALIFIED
45	EC	DEBRUPA PAL	21EC1505	XE9031	A	CS9030	B					QUALIFIED
46	EC	MANALI DHAR	21EC1506	XE9031	A							QUALIFIED
47	EC	PALLAV DUTTA	21EC1507	XE9031	A							QUALIFIED
48	EC	RANJITH DEVULAPALLI	21EC1508	XE9031	A							QUALIFIED
49	EC	ANU SAMANTA	18EC1505			EC9049	B	EC9039	A			QUALIFIED
50	EE	ANANTHAMMAGARI BHARATHSIMHA REDDY	21EE1101	XE9031	B							QUALIFIED
51	EE	ANKUR YADAV	21EE1102	XE9031	A							QUALIFIED
52	EE	ANSHU CHOUDHARY	21EE1103	XE9031	A							QUALIFIED
53	EE	PIKLU DAS	21EE1104	XE9031	B							QUALIFIED
54	EE	SAMUDRA PANDA	21EE1105	XE9031	A							QUALIFIED
55	EE	SAYAK MONDAL	21EE1106	XE9031	A	EE9019	EX					QUALIFIED
56	EE	VIVEK RANJAN	21EE1107	XE9031	A	EE9021	A					QUALIFIED

Dean (Academic Research)
Date: 08-06-2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

OFFICE OF THE DEAN (ACADEMIC RESEARCH)

PROVISIONAL RESULT OF PHD COURSE WORK (EVEN SEMESTER/ SESSION: 2021-2022)

57	EE	SUBHASH CHANDRA PAL	21EE1109	XE9031	A	EE9021	A	EE9042	B	CS9046	A	QUALIFIED
58	EE	SWAGATA KUNDU	21EE1110	XE9031	A	EE9021	EX	EE9042	A	CS9046	A	QUALIFIED
59	EE	SUBIR BHATTACHARYYA	21EE1111			MA9019	B	MA9017	C			QUALIFIED
60	EE	JHUMA KUNDU PAUL	21EE1501	XE9031	B							QUALIFIED
61	EE	SHUKLA KARMAKAR	21EE1502	XE9031	A							QUALIFIED
62	EE	SUBHAJIT ROY	21EE1503	XE9031	A	EE9021	A	EE9019	A			QUALIFIED
63	EE	SUMAN DASGUPTA	21EE1504	XE9031	C	EE9042	B					QUALIFIED
64	EE	SUMIT KUMAR	21EE1505	XE9031	A	EE2011	A					QUALIFIED
65	EE	SUBHADIP MONDAL	20EE1104			EE9042	-	CS9046	F			NOT QUALIFIED IN EE9042 (Absent),CS9046
66	EE	SUDIPTA MAL	20EE1502	XE9031	A	EE9018	A	EE9021	A			QUALIFIED
67	HS	ANINDITA GHOSAL	21HS1101	XE9031	A	HSSR 1004	B	HSSR 1005	A			QUALIFIED
68	HS	SUMANTA PRAMANIK	21HS1102	XE9031	A	HSSR 1004	B	HSSR 1005	A			QUALIFIED
69	HS	SHIBU GORAI	21HS1103	XE9031	A	HSSR 1004	B	HSSR 1005	A			QUALIFIED
70	HS	TANUSHREE MITRA	21HS1104	XE9031	A	HSSR 1004	B	HSSR 1005	B			QUALIFIED
71	HS	SHIBAJI BOSE	21HS1501	XE9031	A							QUALIFIED
72	MA	ABHIJIT MONDAL	21MA1101	XE9031	A	MA9123	A					QUALIFIED
73	MA	ANIRBAN SEN	21MA1102	XE9031	A	MA2101	A					QUALIFIED
74	MA	MAHITOSH MAITY	21MA1103	XE9031	A	MA2001	A	MA2002	A			QUALIFIED
75	MA	PARIKSHIT DAS	21MA1104	XE9031	A	MA9023	EX					QUALIFIED
76	MA	APARNA ADHIKARY	21MA1106	XE9031	A	MA2002	A	MA9021	B			QUALIFIED
77	MA	LOKENATH THAKUR	21MA1107	XE9031	A	MA4101	A					QUALIFIED
78	MA	SUPRIYA MONDAL	21MA1108	XE9031	B	MA4102	A	MA2104	B			QUALIFIED
79	MA	BIKASH KOLI ROY	21MA1111			MA9019	A	MA9017	A			QUALIFIED
80	MA	RATNABALI PAL	21MA1501	XE9031	B							QUALIFIED
81	MA	SATAJIT BHATTACHARJYA	21MA1502	XE9031	A	MA9021	C	MA2002	C			QUALIFIED
82	ME	AKASH KUMAR	21ME1101	XE9031	A	ME9023	A	CS9045	A			QUALIFIED
83	ME	ARUNABHA MAHATO	21ME1102	XE9031	A	ME2014	EX					QUALIFIED
84	ME	DEEPAK KUMAR RAJ	21ME1103	XE9031	A							QUALIFIED

Dean (Academic Research)
Date: 08-06-2022

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OFFICE OF THE DEAN (ACADEMIC RESEARCH)

PROVISIONAL RESULT OF PHD COURSE WORK (EVEN SEMESTER/ SESSION: 2021-2022)

85	ME	GEETA VERMA	21ME1104	XE9031	A	ME2011	EX					QUALIFIED
86	ME	SATENDRA SINGH	21ME1105	XE9031	A	ME9018	B					QUALIFIED
87	ME	SUBHAM SHOW	21ME1106	XE9031	A							QUALIFIED
88	ME	AVISHEK MUKHERJEE	21ME1107	XE9031	A	ME2014	A	ME2011	A			QUALIFIED
89	ME	MEGHNATH SEN	21ME1108	XE9031	A	ME9018	B	ME9020	A			QUALIFIED
90	MM	ANIRBAN HAZRA	21MM1101	XE9031	B	PH2001	B					QUALIFIED
91	MM	AVASH KUMAR SAHA	21MM1102	XE9031	A	MT2001	C					QUALIFIED
92	MM	MOHAMMAD HAMZA	21MM1103	XE9031	A	MT9050	C					QUALIFIED
93	MM	S ARULMOZHISELVAR	21MM1104	XE9031	A							QUALIFIED
94	MM	BIPLLAB CHAKRABORTY	21MM1106	XE9031	A	MT2001	C					QUALIFIED
95	MS	INDU NATH JHA	21MS1101	XE9031	A	MS2001	B	MS2004	EX			QUALIFIED
96	MS	ABHISHIKTA BASAK	21MS1501	XE9031	A	MS2004	EX					QUALIFIED
97	MS	ANWESHA MAZUMDER	20MS1101			MS9053	B					QUALIFIED
98	PH	ANURUP CHAKRABORTY	21PH1101	XE9031	B	PH2001	B	PH1932	A			QUALIFIED
99	PH	IMAN BISWAS	21PH1102	XE9031	A	PH2001	B	PH9032	A	PH9034	B	QUALIFIED
100	PH	MANSI MANDAL	21PH1104	XE9031	A	PH2102	A	PH2103	A			QUALIFIED
101	PH	RAJALAXMI NATH	21PH1105	XE9031	A	PH2001	B	PH2104	A			QUALIFIED
102	PH	SASHIKANTA BARIK	21PH1106			PH2102	C	PH9114	B			QUALIFIED
103	PH	DEBAPRIYA NANDI	21PH1501	XE9031	A							QUALIFIED
104	PH	PREMANSHU SEKHARDEY	21PH1502	XE9031	A							QUALIFIED
105	PH	SURESH DAS	21PH1503	XE9031	B							QUALIFIED
106	BEAT	PINAKI RANJAN DAS	21BEAT1501	XE9031	A	EE9042	A					QUALIFIED

Dean (Academic Research)
Date: 08-06-2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
OFFICE OF THE DEAN (ACADEMIC RESEARCH)
PROVISIONAL RESULT OF PHD COURSE WORK (EVEN SEMESTER/ SESSION: 2021-2022 / NPTEL)

Sl No.	Dept.	Name of the Scholar	Roll No.	Course /Sub. Name	Marks	Course /Sub. Name	Marks	Course /Sub. Name	Marks	Course /Sub. Name	Marks	Remarks
1	CE	MD MOZAFFAR MASUD	21CE1103	FINITE ELEMENT METHOD	99							QUALIFIED
2	CE	SUKAMAL KANTA GHOSH	21CE1105	FINITE ELEMENT METHOD	82							QUALIFIED
3	CE	NEETIKA SAHA	21CE1106	FINITE ELEMENT METHOD	73							QUALIFIED
4	EE	SAMUDRA PANDA	21EE1105	HIGH POWER MULTILEVEL CONVERTERS - ANALYSIS, DESIGN AND OPERATIONAL ISSUES	73							QUALIFIED
5	ME	AKASH KUMAR	21ME1101	FUZZY LOGIC AND NEURAL NETWORKS	77	TRADITIONAL AND NON-TRADITIONAL OPTIMIZATION TOOLS	64					QUALIFIED
6	ME	SATENDRA SINGH	21ME1105	MECHANICS OF FIBER REINFORCED POLYMER COMPOSITE STRUCTURES	81							QUALIFIED
7	MS	DIVYA SINGH	20MS1104	CONSUMER BEHAVIOUR	90	MARKETING ANALYTICS	96	MARKETING RESEARCH AND ANALYSIS-II	80	QUALITATIVE RESEARCH METHODS AND RESEARCH WRITING	66	QUALIFIED

Dean (Academic Research)
Date: 08-06-2022

Regulations for PhD Program

(Revised and Effective from 9th June, 2022)

Amended as per (i) 54th Senate, Item No. 54.18.3, (ii) 56th Senate, Item No. 56.6 (point 1, 2 and 3), (iii) 57th Senate, Item No. 57.12 and Item No. 57.17.3, (iv) 58th Senate, Item No. 58.8, (v) 60th Senate, Item No. 60.5 (point 10.6.21:Item 11(b)) & Item No. 60.9 and (vi) 61st Senate, Item No. 61.12 & Item No. 61.13, (vii) 62nd Senate, Item No. 62.7, (viii) Item No. 62.8 & (ix) Item No. 62.10

&

Office Order No: NITD/60, dt. March 24 & 25, 2021

National Institute of Technology Durgapur

The Institute/ NITD means 'National Institute of Technology Durgapur'

The Student/ Scholar means 'Research Scholar'

1.0. Introduction

1.1. The Institute offers doctoral research program leading to the degree of Doctor of Philosophy (PhD).

1.2. Deleted.

1.3 Notwithstanding any of the clauses provided in the Regulations, the Senate can exercise its powers to amend/interpret/implement decisions and actions concerned with academic matters.

1.4 A joint or collaborative PhD degree may be awarded by NIT Durgapur and another premier academic institution in India or abroad with which NIT Durgapur shall sign a MoU to this effect. However, each such case shall have to be approved by the respective Senate and the Board of Governors.

1.5. All the provisions of the UGC will be covered in the PhD program at NIT Durgapur as far as possible. (UGC Regulations, 2016; The Gazette of India, July 5, 2016, Part III, Section 4)

1.6. The Board of Governors of the Institute may, on the recommendation of the Senate, change any or all parts of the Regulations at any time.

1.7. The medium of communication, instruction, examination, seminars and the defense of PhD thesis will be English.

2.0. Admission

2.1. Status of Research Scholar:

The status of the candidates admitted to the PhD program shall be classified under any one of the following categories:

Category-A. Regular Research Scholar with Institute Fellowship:

Category-B. Regular Research Scholar with financial support from Government Programs (Sponsored by DST, CSIR, UGC, DST-INSPIRE, **etc.)**.
Candidates seeking admission to PhD program having their fellowship from various Government organizations such as CSIR, UGC, DBT, DST-INSPIRE etc. must be supported by a No Objection Certificate from the **Proposed** Supervisor of the Institute.

Category-C. Regular Research Scholar Selected in Externally Funded Sponsored Projects in the Institute (Must be supported by a No Objection Certificate from the Principal Investigator, indicating the duration for which the fellowship is available).

Category-D. Regular Research Scholar under QIP/ EFIP scheme.

Category-E. Regular Foreign Research Scholar Admitted Through Government of India.

Category-F. Professional Research Scholar from the Institute (NIT Durgapur Faculty / Staff): (Must be supported by a No Objection Certificate from the Head of the Institute).

Category-G. Regular Sponsored Research Scholar from Government/ Semi- Government/ other Highly Reputed Organizations/Academic or Research Institutions (Submission of No Objection Certificate / Sponsorship Certificate in the given format is mandatory).

Category-H. Professional Research Scholars from Industries: (Submission of either No-objection certificate or Sponsorship certificate from the employer during the admission process in the given format is mandatory).

Category-I. Professional Sponsored Research Scholars from Academic/ Research Institutions (Must be supported by a No Objection Certificate from the Head of the Institute)

Category-J. Professional Sponsored Research Scholars under Government of India Schemes like TEQIP etc. (will be guided by the norms of the scheme).

Category-K. Regular Research Scholar without Institute Fellowship (Self-sponsored)
(Such scholars will pursue PhD programme at the Institute on full time basis without getting financial assistance from NIT Durgapur or any other funding agency.)

Category L. Regular Research Scholar under Collaborative/Joint PhD Programs.
(Admission of such research scholars under this Category can be taken in both Odd and Even Semesters. Admission of such research scholars shall be made as per laid down terms and conditions in the MoU with respective institute/organization.)

The interested applicants can apply under various centres of the institute as listed below under categories B, C and K.
The interested applicants can apply under various centres of the institute under categories B and C, if they have their own fellowships and / or applying from a project, which was funded under the centres of the institute (relevant documents are to be provided by the respective Centre Coordinator).

List of Centres of the Institute:

(i) Centre for Research on Environment and Water (CREW)
(ii) Centre for Biomedical Engineering & Assistive Technology (BEAT)
(iii) Centre for Advanced Research on Energy (CARE)
(iv) Centre of Excellence on IoT and Intelligent Systems (IoTIS)

The interested applicants can also apply in the professional category for PhD studies in the above four Centres of Advanced Research.

Beside above categories, admission of research scholar from foreign institution/organization shall be made as per laid down terms and conditions in MoU with respective institute / organization.

The PhD degree awarded to all categories of students shall be treated as the same and equivalent.

2.2. Eligibility for Admission

2.2.1 The minimum qualification required for admission to Ph.D. program is one of the following:

<table>
<tr><th>Qualifying Degree*
(for relevant discipline)</th><th>General/ OBC</th><th>SC / ST</th><th>Academic and other Qualifications</th></tr>
<tr><td>M. Tech./ M.E./ M. Arch/ M. Pharm / M. S. / MBA/ PGDBM/ PGDM</td><td>6.5 CGPA or 60% marks</td><td>6.0 CGPA or 55% marks</td><td rowspan="6"><u>Category A:</u>
B. Tech/ B.E./ B. Arch/ B. Pharm / Equivalent with valid GATE.
M. Tech./ M.E./ M. Arch/ M. Pharm degrees with or without GATE qualification.
Other Post Graduate or Graduate degrees (as listed) with any relevant NET qualification.
List of NETs:
CSIR, UGC, GATE, GPAT, DBT-JRF, JEST, ICMR, ICAR, NBHM, Bioinformatics National Certification Examination etc. However, these NET qualifications will have to be relevant to the qualifying degree of the candidate concerned.
(OM No. SB/S9/2-01/2015 dated 07.01.2015)

<u>Categories B, C, D and E:</u>
As per the terms and conditions of the funding or sponsoring agency.

<u>Categories F, G, H, I, J, and K</u>:
Same as category A, but GATE/NET qualification is not mandatory.

<u>Category L</u>: As per MoU</td></tr>
<tr><td>M. Sc./ M. Com./ MBBS/ BDS</td><td>6.5 CGPA or 60% marks</td><td>6.0 CGPA or 55% marks</td></tr>
<tr><td>MA</td><td>6.0 CGPA or 55% marks</td><td>5.5 CGPA or 50% marks</td></tr>
<tr><td>MCA</td><td>7.5 CGPA or 70% marks</td><td>7.0 CGPA or 65% marks</td></tr>
<tr><td>B. Tech/ B.E./ B. Arch/ B. Pharm / Equivalent</td><td>7.5 CGPA or 70% marks</td><td>7.0 CGPA or 65% marks</td></tr>
<tr><td>CA/ ICWAI/ CS with a graduation degree</td><td>6.0 CGPA or 55% marks</td><td>5.5 CGPA or 50% marks</td></tr>
</table>

*All the degrees will be from an institute / university recognized by UGC/AICTE/MoE.
The preceding qualifying degrees of the candidates required for admission shall be decided by the respective DRPC. The minimum eligibility criteria for admission to professional PhD program 2019-20 onwards will be same as full-time PhD program under Category A. However, qualification in National Eligibility Tests etc., is not mandatory for professional PhD program.

2.2.2. Scholars under categories C and F must submit a no-objection certificate from the PI of the project/Institute during admission. They shall work for the Ph.D. program without affecting their normal duties.

2.2.3. Research scholars of categories G, H, I and J shall submit a Sponsorship and/or No-objection certificate, as applicable, from the employer during admission. In case the candidate joins a new organization, submission of a fresh NOC obtained from them is mandatory.

2.2.4. Deleted.

2.2.5. Mere possession of required degree and a good academic record does not guarantee admission to a candidate for the Ph.D. program. Apart from academic record, the DRPC will take into consideration the research aptitude, ability to work in a team, subject interest, availability of supervisors, facilities in the department and the research focus of the department while selecting candidates to the Ph.D. program through a pre-defined process.

2.3. Residential Requirement

2.3.1. Normally all full-time candidates admitted to the Ph.D. program will be required to stay in the Institute till they complete all assigned work and submit thesis.

However, for full-time candidates sponsored from Government / Semi-government / major industry with established R&D facilities, the DRPC may recommend to reduce the minimum residential requirement to one year or higher (for completing the course work and formulating the research problem).

2.3.2. If a full-time sponsored candidate intends to carry out a major part of his research work in his place of employment, she/he must convince the DRPC at the time of selection that adequate research facilities and research tradition exist in her/his organisation. While taking the decision DRPC will examine all the documents presented to it regarding adequacy of the R&D facilities available in the sponsoring organisation. These documents have to be furnished by the candidate during the time of interview.

In general major Central Govt. (CSIR, DRDO, DAE, ISRO, CDRC etc.) labs, research organisations, industries (public or private) with established R&D facilities are taken as organisations with adequate facilities.

Regarding recognition of other organisations the DRPC has to make a recommendation on the basis of the material available to it to the Director through Dean (Academic Research) for approval. In every case, the Senate will decide the residential requirement.

2.3.3. All Ph.D. (Professional) students including categories H, I and J students are mandated to have contact with the supervisor(s) for discussion and research in the Institute for at least 90 days a year in a single/multiple visit/s.

2.4. Admission procedure

2.4.1. Admission of scholars under categories A and B shall be made once in each semester as per a pre-decided schedule indicating the total number of seats available. Dean (Academic Research) will publish the admission notice on the Institute website. The departments will screen the applications based on pre-defined criteria sent by the Academic Section and prepare the shortlist. They will conduct admission tests (for category A), followed by shortlisting based on pre-defined criteria, if needed, and viva voce, and select the candidates on the basis of overall academic performance, written test and viva voce. The department will send the list of selected candidates to the office of the Dean (Academic Research). One expert from other department, selected from a panel of experts nominated by Director, will act as an observer in the viva voce.

2.4.2. Admission of scholars under categories C shall be made once in each semester along with the scholars under categories A and B. The candidate shall submit the application through the Dean (R&C) in the prescribed format of Sponsored Research and Consultancy Cell (SRCC) on recommendation of concerned PI and Head of the Department/Centre. The selection procedure will be the same as category A.

2.4.3. (i) Admission under categories F, G, H, I and J shall be made once in every academic year, during Odd Semester only.
(ii) F**oreign/NRI candidates from foreign institution/organization not having MoU with NIT Durgapur** shall be treated at par with the candidates from foreign institutions/organizations having MoU with NIT Durgapur.

2.4.3.1. The admission under categories F, H and J shall be made directly subject to fulfillment of eligibility criteria fixed by the respective departments, and submission of requisite documents and no-objection/ sponsorship certificate. The admission shall be subject to the availability of suitable supervisor(s) and the endorsement by the department.

2.4.3.2. Admission of candidates under categories G and I shall be made against the admission notice on the Institute website. The departments will conduct admission tests and viva voce, select the candidates on the basis of overall academic performance, written test and viva voce and send the list of selected candidates to the office of the Dean (Academic Research). Dean (Academic Research) shall publish the selection list on the Institute website. The candidates need to produce a sponsorship / No objection certificate in the prescribed format of the Institute during the admission test. For the category I, a Board of external examiners shall be constituted by the Chairman, Senate for the selection process.

2.4.3.3 Admission of candidates under category K shall be made once in each semester against the admission notice on the Institute website.
(i) **Minimum required qualification**: The minimum qualification required for admission to PhD program for Category K is the same as that of Category A but GATE/NET qualification is not mandatory.
(ii) **Admission Process**: The admission process will be the same as that of Category A, as per PhD regulations.
(iii) For the matters other than those mentioned in the above points Nos. 2.4.3.3. (i) & (ii), all other existing rules applicable to Category A scholars will be applicable to the Category K scholars as per PhD regulations or as prescribed by the Institute time to time.
(iv) The direct conversion of Scholar from the Category K to Category A and vice versa will not be permitted.
(v) A “Self-declaration” for unemployed/self-employed or “No Objection Certificate” from the employer for employed candidate is to be submitted during the admission process.

2.4.3.4 Admission of candidates under category L shall be made as per MoU.

2.4.4. Admission of research scholar from foreign institution/organization shall be made as per laid down terms and conditions in MoU with respective institute / organization during the Odd Semester only.

2.4.5. Applications of candidates shall be received by the office of Dean (Academic Research) and forwarded to the departments for screening. Dean (Academic Research) shall publish the short-list of the candidates screened by the departments on the Institute website along with the date, time and venue of the admission test and viva-voce.

2.4.6. Dean (Academic Research) shall publish the selection list on the Institute website. All communication related to the admission procedure shall be made through the Institute website **www.nitdgp.ac.in** only. Regular reservation policy of the Government of India shall apply.

2.4.7. All selected candidates will fill in the admission form (vide **INFORMATION SHEET** (**PAIS**), FORM-1) and submit an undertaking that she/he would abide by all rules and regulations and codes of conduct of the Institute.

2.4.8. Respective departments shall be responsible for the selection of research scholars.

2.5. Withdrawal from Residency

2.5.1. A sponsored student, pursuing PhD by staying on campus, can become non-resident by taking withdrawal from the residency. She/he may return to his place of work on completion of residential requirement, provided that such a scenario was mentioned in his application for admission and the student has a co-supervisor from his place of employment. The minimum period of work will be extended by one year, except when the student is employed in a superior R&D organization and is engaged in full time research on the same topic as his PhD works. The Joint/ Deputy Registrar (Academic & Examination) will issue a withdrawal order.

2.5.2. When a regular PhD student received the registration number fulfilling all the registration requirements and she/he gets a new job, she/he should apply through DSC for withdrawal of residency. However, the No Objection Certificate must be submitted from the employer.

2.5.3. In case of students, who secure a new job or otherwise wish to move outside the institute and end their doctoral program prematurely, need to refund any scholarship received.

3.0. Supervisors (to be read with clause 17.4)

3.1. The assignment of Ph.D. students to supervisor(s) by DRPC and constitution of Doctoral Scrutiny Committee (DSC) following enrolment/admission of the Ph.D. students will be made within a period of fifteen days from the date of enrolment. Chairperson (DRPC), in consultation with the supervisor/co-supervisor(s), shall constitute the DSC (vide DOCTORAL SCRUTINY COMMITTEE (DSC), FORM-3). The supervisor/co-supervisor(s) shall finalize the broad (tentative) title of the research topic of a selected candidate after mutual discussion.

3.2. All supervisors/co-supervisors of Ph.D. program shall be at least in the rank of Assistant Professor or equivalent having a Ph.D. degree. If a person from outside the Institute, not satisfying these criteria, is proposed to be a co-supervisor, the matter shall be referred to the Senate for decision.

3.3. The weightage of a joint PhD supervision by more than one supervisors shall be considered to be 0.5 while counting the number of total PhD supervision by a faculty member. The maximum permissible total number thus computed shall, however, not exceed six.

3.4. There can be one supervisor and maximum one co-supervisor for a research scholar from the Institute, with maximum one additional co-supervisor from outside.

3.5 The supervisor/co-supervisor must be a regular faculty member of the Institute belonging to the department in which the research scholar will be registered for doctoral studies.

3.6. The co-supervisor(s) may be from the same department of the Institute or other departments / outside.

3.6.1. A person from abroad satisfying the qualification criteria may become a co-supervisor. NIT Durgapur will have, however, no financial responsibility, whatsoever, in the research visits, if any, required for the collaborative research.

3.6.2. Deleted.

3.6.3. Co-supervisors from other institutions/ organizations shall submit curriculum vitae, a consent letter and a no-objection certificate from the employer during formation of DSC, if they do not have MoU with NIT Durgapur.

3.7. Any change in supervisor/co-supervisor shall have to be recommended by the DSC and forwarded to the office of Dean (Academic Research) for approval of Senate.

3.7.1. Change of supervisor/co-supervisor under exceptional circumstances shall be permitted on the recommendation of the DSC, subject to the consent of the research scholar, the present supervisor/co-supervisor and the proposed supervisor/co-supervisor. However, the candidate shall not be permitted to present pre-submission seminar within one year from the date of change of supervisor/co-supervisor.

3.7.2. Addition of co-supervisor shall be permitted on the recommendation of the DSC, subject to the consent of the research scholar. However, the candidate shall not be permitted to present pre-submission seminar within one year from the date of addition of supervisor/co-supervisor.

3.8. When a supervisor leaves the Institute permanently or temporarily for a period exceeding 6 months, the DSC shall appoint a new supervisor for the research scholar before her/his departure.

3.9. Deleted.

3.10. The DSC may consider continuation of the original supervisor on her/his return to the Institute as one of the supervisors.

3.11. A supervisor/co-supervisor after superannuation shall continue to act as the co-supervisor. However, if the research scholar has no supervisor from the department in which she/he is registered, one faculty member of the same department shall be made the supervisor after consultation with the superannuating supervisor and the research scholar. In case of the candidate already presented pre-submission seminar successfully, no additional supervisor shall be necessary.

4.0. Semester Registration

4.1. A student enrolled in the Ph.D. program will be required to register every semester along with endorsement of satisfactory progress by the DSC (vide Ph.D. SEMESTER REGISTRATION FORM (PSRF), FORM-2) and by paying tuition fees and other Institute dues. The Semester registration is different from PhD registration. A research scholar shall appear before the DSC at the end of each semester to make a presentation of the progress of his/her work for evaluation and further guidance. The DSC shall submit the approved progress report along with the registration form to the Academic Section.

4.2. Sponsored students who have been sanctioned withdrawal also need to do semester registration. They may, however, be permitted to send registration form by post to their supervisor, who will present them to the Academic Section through the HOD.

4.3. Failure to do semester registration within the stipulated dates as per Academic Calendar will result in termination of studentship, which in a very special case can be restored by the Senate on consideration of all circumstances, payment of additional fines and extension of thesis submission date.

4.4. It shall be the responsibility of the student to bring any deviation in his status in matters of course work, registration, withdrawal etc. to the attention of Dean (Academic Research) at the time of semester registration, if she/he has not done so earlier.

4.5. A student may be exempted from semester registration by Dean (Academic Research) / Director if she/he submits thesis within 30 days of scheduled semester registration. However, the student will lose his fellowship (if any) during the said period. If she/he fails to submit the thesis within 30 days, she/he must do the semester registration before the thesis is accepted for evaluation.

4.6. When the examined PhD thesis require revision and sent back to the examiner or the PhD thesis is not recommended / rejected by the examiner, the scholars have to pay semester registration fees to keep his / her studentship valid for the period till his / her thesis is recommended by the examiners. However, the scholarship will not be revived for such cases.

5.0. Ph.D. Registration

5.1. Every student enrolled in the Ph.D. program is given provisional admission soon after his/ her enrolment. The provisional admission defines:
(a) The broad area of research and

(b) The course work to be carried out by the student.
The student continues to work for close to a year before his research plan is properly formulated.

5.2 An enrolled Ph.D. student will be formally registered (vide Registration Form for Ph.D. Programme, FORM-5) for the degree of Ph.D. on completion of following steps:
(a) The candidate has successfully completed all assigned course work,
(b) Worked out a road map of the program and submitted a formal work plan to the DSC and
(c) Delivered an open seminar (Pre-registration seminar) to the satisfaction of the DSC. A tentative research title should be indicated in this seminar.

5.3. Subsequent to obtaining a favourable recommendation from the DSC, the Ph.D. registration fee (as applicable at the time) shall be paid by the candidate. The date when the candidate deposits the PhD registration fee shall be treated as the date of registration.

5.4. The registration of Ph.D. candidates may be approved by Chairperson, Senate and be ratified by the Senate in its subsequent meeting.

5.5. Candidates should normally present the registration seminar not later than five semesters from the date of enrolment, failing which the registration shall be cancelled.

5.6. The final title of Ph.D. thesis shall have to be indicated in the synopsis of the Ph.D. thesis at the pre-submission seminar and shall have to be approved by the DSC, along with the final synopsis of the Ph.D. thesis (clause 7.3).

6.0. Course Work

6.1. Course work is compulsory for all students enrolled for Ph.D. program including those with Master Degree in the same discipline. PhD scholars will have to qualify all the course work as assigned by the DSC.

6.2.1 (i) All Ph.D. scholars are required to qualify the course "Research Methodology".
(ii) PhD Students those are admitted under the MoU as well as other Professional PhD Students shall take Research Methodology course offered by NIT Durgapur or by an IIT/NIT/IISER/IISc/CFTI for which request letter shall be sent by NIT Durgapur to the concerned institute on behalf of the candidate. Other courses may be taken at NIT Durgapur or online (NPTEL, MOOCS, etc.).
6.2.2 The DSC will prescribe additional courses as follows (applicable for candidates admitted in the Academic Session 2021-22 onwards):
i) Scholars with M. Tech./ equivalent degree - Minimum 9 credits plus Research Methodology.
ii) Scholars with B. Tech./ MSc/ MA/ MCA degree - Minimum 16 credits plus Research Methodology.
iii) While this is a general guideline, the DSC may decide on higher credits requirement.
iv) Online courses offered by MOOCS/ NPTEL etc. and conduct online examination may also be utilized for the purpose of credit requirement, as assigned by the DSC.

6.3. Deleted
6.4. The scholars admitted to the Ph.D. programs shall be required to complete the coursework prescribed by the DSC within the first four semesters. Any extension will require the approval of the Senate.

6.5. The scholars will take courses based on the recommendation of the supervisor/co-supervisor(s) and approved by the DSC. The list of courses to be taken by a research scholar during a particular semester shall be endorsed by the DSC and informed to the Dean (Academic Research) within seven days from the start of the semester or within seven days from the date of enrolment. In case a course is taken from another department, it is to be endorsed by the Head of the concerned Department.

6.6. The scholars enrolled in courses are subject to the same regulations as applicable to other students in the courses with regard to attendance, grading, discipline and assessment.

6.7. The concerned teachers shall forward the grades of the research scholar at the end of a semester to the Associate Dean (Academic Research) for publication of results.

6.8. The scholar must pass each of these courses with at least C grade in a 7-point scale / equivalent. The result will be published as "QUALIFIED" for grades obtained 'C' and above and as "NOT QUALIFIED" for grades obtained below 'C'. A student shall get maximum three chances to pass a course assigned by the DSC, through grade improvement examinations which will be held concurrently with supplementary examinations of other academic programmes.

7.0. Submission of Thesis

7.1. The research scholars of all categories shall normally submit their Ph.D. thesis within a period of six years from the date of enrolment in the Ph.D. program. However, for satisfactory reasons, the period may be extended by one more year. The female scholars and Persons with Disability (more than 40% disability) shall be allowed a relaxation of two years in the maximum duration. However, the fellowship tenure shall be applicable as per the guidelines of the MoE / sponsoring agency.
The extension shall have to be recommended by the DSC. In case, no extension for registration is applied for the registration shall automatically stand terminated at the end of the above-stipulated period.

7.2. A research scholar shall submit his/her Ph.D. thesis not earlier than two years from the date of registration in the PhD program.

7.3. Prior to submission, when the thesis is nearly ready and can comfortably be submitted within three months the scholar will submit the synopsis of the thesis [typically 10 pages including tables, graphs and references] and present a seminar to an open audience (pre-submission seminar), which will include members of DSC. Soft and hard copies of the thesis should be submitted to the members of the DSC at least one week before the date of the seminar.

7.4. The DSC shall assess the work through a pre-submission seminar in presence of all supervisor/co-supervisor(s). It is mandatory that all the supervisor/co-supervisor(s) are present during the seminar. The DSC should confirm that the scholar has completed the required number of courses. The scholar shall respond to the suggestions of every DSC member. If and when the DSC is satisfied with the extent of work done and the quality of the thesis the scholar will be allowed to submit the thesis. The DSC shall forward one hard copy, signed by the scholar and the supervisor/co- supervisor, and a soft copy of the synopsis of the PhD thesis along with recommendations (vide EVALUATION REPORT ON PRE-SUBMISSION SEMINAR FOR Ph.D. THESIS, FORM-7) to the office of Dean (Academic Research).

7.5. (i) The scholar must have at least two papers published / accepted for publication based on his/her doctoral research in a SCI/ SSCI/ AHCI/ Non-paid Scopus/ Web of Science journal and

preferably two paper presentations in conferences/ seminars before the submission of the dissertation/ thesis for adjudication, and produce evidence for the same in the form of presentation certificates and/or reprints.
(ii) A journal publication by a PhD student without any of her/his supervisor(s) as one of the author(s) can be included in her/his PhD thesis with the approval of the supervisor(s).

7.6. A general format and guidelines (Clause 19.0) shall be used for writing Ph.D. thesis.

7.7. Plagiarism check shall be made for Ph.D. thesis to satisfy maximum permissible match of 20% excluding publications of the research scholar and corresponding supervisor/co-supervisor(s). The plagiarism check certificate should be included in the thesis.

7.8. The thesis examination fee, as applicable at the time, shall be deposited, subject to completion of all formalities.

7.9. The research scholar shall submit two copies of the Ph.D. thesis (hard-bound cover) for the external examiners to the office of the Dean (Academic Research) within three months from the date of successful pre-submission seminar. The soft copy of the thesis shall be emailed to Dean (Academic Research). After successful defense of the thesis and incorporation of revision as per the comments of the examiners, the candidate shall submit one hardbound copy of the final version and a soft copy of the Ph.D. thesis to the office of Dean (Academic Research).

7.10. Electronic copies of the theses should be posted on Institute web site for wide distribution.

8.0. Examination of PhD Thesis *[applicable to all scholars]*

8.1. The DSC shall prepare and submit two panels of five external examiners each in the area of the submitted research work each from India and abroad, to Dean (Academic Research) in hard and soft copies, for the appointment as external examiners of the thesis. The list must include the name, designation, affiliation, full postal address, telephone number, email IDs and webpage address of the examiners. The examiners should be selected by the DSC from amongst the eminent faculty members or experts, Professors / Associate Professors/ Retired Professors / Emeritus Professors, and researchers with Ph.D. in Institutes / Universities / Research laboratories / Industries of repute. The area of his/ her specialization is to be mentioned explicitly along with a hyperlink to his/ her web page. In the list of examiners from abroad, there shall be at least three experts not of Indian origin. The name of a person who is a co-author with the research scholar in any of her/his publications (Journal/Conference/Patent) at any time should not be recommended by the DSC as External Examiner for evaluation of the Ph.D. thesis of the scholar. **There should not be any conflict of interest in the selection of the panel of examiners**.
It shall also include the name and registration number of the research scholar, thesis title, the department registered and the name of the supervisor/co-supervisor(s) etc. (vide Ph.D. THESIS SUBMISISON FORM, FORM-8). Director as the Chairperson of the Senate shall select one external examiner each from India and abroad from the recommended panel.

8.2. It is expected that the DSC submits the panels of examiners immediately after the pre-submission seminar to the Dean (Academic Research), so that the consent of examiners is obtained before submission of the thesis.

8.3. Dean (Academic Research) will arrange to dispatch the synopsis to the external examiners by email. On receipt of their acceptance to become the external examiner of the Ph.D. thesis, the Academic Section will arrange to dispatch the thesis to them by e-mail/post. The soft copy of the

Ph.D. thesis shall also be sent through email. Normally, the examiner will be required to submit the evaluation report within six weeks.

8.4. Deleted.

8.5. When a thesis is unanimously accepted by the board of examiners for the award of the Ph.D. degree (Annexure-IX), the scholar shall be required to defend the work in an open seminar followed by a viva-voce conducted in presence of the external examiner from India. DSC members and other interested persons. It is not mandatory for the co-supervisors from abroad to be present during the viva voce. In case the Indian external examiner is not able to attend the seminar and viva-voce, Director shall appoint an alternate examiner for the purpose from the existing panel of external examiners from India. The defense of the thesis shall be held after at least three weeks from the date of dispatch of the thesis.

8.6. If an external examiner does not respond within three weeks from the date of dispatch of the synopsis or within three months from the date of dispatch of the thesis, Director may select an alternate name from the recommended panel of Experts as the external examiner. The examiners may be reminded of sending the report of the thesis after two months of dispatch of the thesis. The examiners may send the report on the thesis by email and / or post with a “confidential” label on the mail.

8.7. (i) In case where an examiner criticizes a Ph.D. thesis strongly but still recommend it as “To be revised but need not be sent back to the examiner”, the DSC shall take utmost care to ensure that all suggested revisions and concerns of the examiner have been addressed in the revised thesis.
(ii) If a thesis in the present form is not found to be acceptable by any one of the external examiners for award of the Ph.D. degree and is likely to be accepted after revision in line with the modifications suggested by the external examiners in their report, the research scholar must re-submit the thesis, after making payment of necessary re-submission fees, incorporating the suggested amendments within three months from the date of the earlier decision of the DSC.

8.8. If a thesis is recommended by one external examiner for the award of the Ph.D. degree but is rejected by the other external examiner, the thesis may be sent to another examiner. The DAC, if needed, may submit a fresh panel of external examiners. The research scholar may submit another copy of the thesis after depositing an additional thesis examination fee, as applicable at the time.

8.9. If a thesis is rejected by both the external examiners, or if it recommended by one examiner but is rejected by two examiners consecutively, the student shall submit a fresh thesis after a period of one year from the date of the decision. The thesis examination fee of as applicable at the time shall be deposited again before the submission of the thesis. The DAC will recommend a fresh panel of external examiners in the area of the submitted research work each from India and abroad for appointment as external examiners of the thesis.

8.10. The thesis resubmission fees will have to be paid as applicable from time to time as stated in the clauses 8.7, 8.8 and 8.9.

9.0. Defense of Ph.D. work

9.1. The Dean (Academic Research) shall invite the examiners, on approval of Chairman, Senate.

9.2. Open Ph.D. seminars and viva will be conducted at respective departments in presence of DSC members.

9.3. Recommendations of the external examiner and DSC will be forwarded to the Dean (Academic Research) for its onward submission to the Chairman, Senate (vide REPORT ON VIVA-VOCE & DEFENSE FOR Ph.D. DEGREE, FORM-14).

10.0. Award of Degree

10.1. On the recommendation of the Doctoral Scrutiny Committee, the Senate or the Chairperson, Senate (when the Senate is not sitting early) shall decide whether the candidate should be awarded the degree of Doctor of Philosophy. If the Chairperson, Senate has approved the award of degree, the award needs to be confirmed by the Senate.

10.2. Deleted

10.3. A provisional degree certificate will be issued by Dean (Academic Research) to the scholar on successful defense of the thesis stating that the candidate has successfully defended her/his Ph.D. thesis fulfilling all the conditions stipulated by the Senate of the Institute. The final degree certificate will be issued in the convocation or by any other mode approved by the Senate. The date of the defense examination shall be the effective date of award of degree and will be mentioned in the provisional certificate and degree certificate.

10.4. Any deliberate false statement or plagiarized text will lead to summary disqualification, in addition to other punitive measures commensurate with the offence. Degrees, even after being awarded, may be revoked if gross violation of academic ethics is established.

10.5. Posthumous Ph.D. degree will be awarded to a deceased student only if the formalities up to the receipt of the 'RECOMMENDED' reports from both examiners (from India and abroad) are completed and the compliance report is submitted. Each such case will, however, need the recommendation of the Senate.

11.0. Fellowship *[applicable to Institute scholars, Category A]*

10.1. Institute doctoral fellowships shall be governed by the rules of MoE. When the number of Institute fellowships is limited; they will be distributed among different departments by the Director on recommendation of Dean (Academic Research). Generally, the number of fellowships will be proportional to the faculty strength, but changes can be made to ensure that the positions are filled to the extent possible.

11.2. In case of students awarded a scholarship by an external agency or from a research project operating in the Institute; the provisions specified by the sponsor shall govern the rules.

11.3. Deleted

11.4. Deleted
11.5. Deleted.

11.6. The scholarship for the category A students shall normally be given initially for a period of three years, which can be renewed on year-to-year basis on satisfactory performance up to a maximum period of 5 years (including project fellowship, if any) / tenure of the research scheme. The scholarship shall, however, automatically be terminated after the date of Ph.D. thesis defense or 5 years from the date of enrolment whichever is earlier.

11.7. Enhancement in rate of fellowship, after two years of enrolment, may be considered on successful assessment by the DSC and submission of report (vide EVALUATION REPORT FOR ENHANCEMENT OF FELLOWSHIP FOR Ph.D. DEGREE, FORM-6) to the Dean (Academic Research) towards satisfactory progress in the research activity. The student will submit a summary of the progress of the work to the Chairperson, DSC through the supervisor/co-supervisor(s) and deliver an open seminar. In case the recommendation of the DSC is not favourable, the candidate may deliver a fresh seminar after six months from the previous one for consideration of enhancement in scholarship. Enhancement of scholarship shall be effective from the date of successful enhancement seminar.

11.8. Deleted.

11.9. If a student with Institute fellowship fails to complete registration formalities within 24 months of enrolment, payment of fellowship will be suspended (with permanent loss) till registration formalities are over.

11.10. All research scholars with fellowship (Institute sponsored/ Externally funded, including UGC/ CSIR/ DST etc.) will be required to assist the Department in teaching activity (sessional, laboratory etc.) and other academic activity for up to 8 hours per week; the quantum of such contribution being decided by the administration from time to time.

11.11. Change of fellowship, other than project fellowship (due to completion of project duration), shall not be permitted.

12.0. Leave rules [*applicable to Institute scholars, Category A*]

12.1. A research student, except when granted withdrawal by the Institute must attend to his work on a whole time basis. The departments will maintain attendance record of the student. The DSC will examine the attendance record of students, and if it is found unsatisfactory, will recommend extension of minimum duration for submission of thesis, deregistration or termination of studentship, as it thinks fit.

12.2. Research scholars other than Institute employee are eligible to enjoy 30 days leave as and when necessary in a calendar year.

12.2.1. Request for the sanction of any type of leave, formal application should be addressed to the HOD which should usually be recommended and forwarded by the supervisor before availing any leave excepting exigencies.

12.2.2. The HOD and his/her office would take care of the leave applications and approvals. The same office would also keep the records of the leave as usual and submits the attendance report to the appropriate authority for scholarships or other grants. The HOD may refer appropriate cases to the Dean (Academic Research) to issue leave certificate, as and when required, and to settle and dispute or cases of exigency.

12.2.3. Leaves of research scholars under CSIR/UGC/DST sponsored research schemes and other categories will be governed by the rules of the bodies, which provide financial support.

12.2.4. In case of medical leave, the Institute Medical Officer must endorse the medical certificate.

12.2.5. Maternity and child care leave are applicable to female student only. A female student is entitled to avail maternity leave for a maximum of 180 days and childcare leave for a maximum of 60 days once during the tenure of their studentship. Similarly, a male student is entitled to avail paternity leave for a maximum of 15 days. If availed, the loss of days due to these leaves may be augmented by extending their registration period, by the same number of days, on the basis of written prayer from the scholars to the Dean (Academic Research) with due recommendation of DSC.

12.2.6. There will be no loss of scholarship/fellowship for the female students availing the maternity and childcare leave but the total time period of scholarship will remain same and will not be extended.

12.2.7. In all cases, an application for medical/maternity leave must be accompanied by all relevant medical papers - prescriptions, admission and discharge reports, diagnostic reports, medicine purchase slips etc.

12.2.8. All leave application must be filed within 3(three) working days after joining.

12.2.9. Absence without sanctioned leave will entail loss of financial assistantship for the period of absence and may result in the termination of the students' program.

12.3. There shall be no summer or winter vacation for research students.

12.4. For part of a year, the entitlement will be on pro-rata basis.

12.5. In matter of course work, leave rules applicable to other program will also be applicable to Ph.D. students.

12.6. Leave on duty - If a scholar require to visit any laboratory/ institute in connection to his/ her research work, such absence from NIT Durgapur will be treated as leave on duty. However, the scholar will require to have prior approval for the same, on recommendation of the concerned supervisor, from the Chairman of DSC (up to 7 days) or Dean (Academic Research) (more than 7 days up to 30 days) or the Chairman, Senate (more than 30 days).

13.0. Miscellaneous

13.1. All seminars and viva voce for the Ph.D. program shall be open house, with a notice normally circulated to all departments of the Institute at least seven days in advance.

13.2. All seminars; pre-registration, enhancement and pre-submission seminars must be conducted within a maximum period of one month from the date of application by the candidate, subject to concurrence of the DSC.

13.3. If the DSC finds the performance of the research scholar unsatisfactory, it will give at least two warnings (in writing) to the candidate. If there is no improvement in her/his performance even after the warnings, the DSC may recommend termination of the Ph.D. program for the scholar through DRPC for approval of the Senate.

13.4. The Institute may revise the fee structure from time to time.

13.5. The list of documents, which need to be submitted at various stages of Ph.D. program starting from the time of admission are listed in Annexure- forms.

13.6. External co-supervisors will submit a willingness certificate (FORM 16/ as per Format) and no objection certificate (FORM 17 / as per Format) from their organization and from their end during formation of DSC or at a time when appropriate.

13.7. The Institute shall submit the soft copy of the thesis to the INFLIBNET after the approval of the award of the PhD degree.

13.8. The Institute will issue a declaration to the effect that the degree has been awarded in accordance with the provisions of UGC regulations, 2016, if sought by a degree awardee.

14.0. Termination of Studentship *[applicable to all students]*

The studentship of a Ph.D. scholar may be terminated by the Senate on exceptional grounds. They are:

- Recommendation of Institute‘s Disciplinary Committee.
- Failure to do semester registration.
- Failure to complete registration within two years from the date of enrolment.
- Poor progress as noted by DSC. Such a decision may be implemented only after approval of the Senate.
- Prolonged absence (exceeding two months) from the Institute without prior intimation.

15.0. Transition issues

The revised/amended regulation shall come into effect from Aug. 21, 2021. Students enrolled prior to this date shall be generally covered by the regulation in vogue at the time of their enrolment. However, some of the clauses in the present regulation shall be applicable to them where these are specifically mentioned. The final decision on each specific issue will be taken by the Senate (or Chairman Senate on its behalf), on case-to-case basis.

16.0. Exceptions

Notwithstanding anything stated in the rules, the Senate can make special provisions and exceptions depending on the merit of a case. Such cases shall not be cited as precedence in future occasions of similar nature, because two situations appearing similar may not be identical.
In emergency situations, the Director in capacity of the Chairman Senate, can exercise powers of the Senate and discharge the functions of the Senate. Such decisions must be reported to the Senate at its next meeting.

17.0. Committees / Functionaries

The following committees shall be constituted for the research program.

17.1. Research Academic Committee (RAC)

17.1.1. Constitution:
i) Dean (Academic Research) - Chairperson
ii) Dean (R&C) - Members

iii) Chairman of all DRPCs OR any one faculty (with Ph.D.) nominated by Chairman of respective DRPCs- Members
iv) One representative with Ph.D. degree from industry / R&D organization - Member
v) Associate Dean (AR)- Member
vi) Joint/Deputy Registrar (A&E) - Convener

17.1.2: Functions:
i) To consider the recommendations of the DRPC on matters relating to research program and to make suitable recommendations to the Senate.
ii) To ensure that all norms and regulations pertaining to research programme are strictly followed
iii) To make periodic review of ordinances, regulations and instructions pertaining to research program and to recommend to the Senate any modification thereof.
iv) To review the academic performance and make suitable recommendations to the Senate regarding the award of degrees.
v) To conduct at least one meeting each semester and send the proceedings to Secretary, Senate.
vi) The quorum for each meeting will be ten.

17.2. Departmental Research Program Committee (DRPC)

17.2.1. Constitution
i) Head of the Department- Chairperson
(In case, Head of the department does not possess Ph.D. degree, the Director shall nominate Chairperson)
ii) All faculty members of the department having Ph.D. degree- Members
iii) One Professor from a premier national academic institution /
one expert from industry / R&D organization with Ph.D. degree- Member

17.2.2. Functions
i) To ensure academic standard and excellence of the Ph.D. program offered by the department.
ii) To assign the supervisor/co-supervisor(s) to the research scholar in consultation with the Scholar and the supervisor/co-supervisor(s)
iii) To conduct admission test/ interview
iv) To consider any general matter related to the research program of the department and propose change in policy pertaining to the Ph.D. program.
v) The external expert to be present in the non-routine DRPC meetings where policy decisions are recommended.

17.3. Doctoral Scrutiny Committee (DSC)

There shall be a Doctoral Scrutiny Committee for each Ph.D. scholar. The Supervisor shall be the Convener of this Committee. The DSC shall vigilantly monitor the quality of the research work and the Ph.D. thesis.

17.3.1. Constitution
i) Chairperson (DRPC)/ A senior Faculty member of the Department
(if Chairperson is a supervisor/co-supervisor) – Chairperson
ii) Two faculty members of the department having PhD degree- Members
iii) One faculty member in the rank of Professor/ Assoc. Professor having Ph.D. from other department of the institute, preferably having interest in related area of research- Member
iv) Concerned supervisor/co-supervisor(s) for the research scholar- Member(s)

17.3.2. Functions

i) To review the research proposal and finalize the topic of research;

ii) To guide the research scholar to develop the study design and methodology of research and identify the course(s) that he/she may have to do.

iii) To periodically review and assist in the progress of the research work of the research scholar.

iv) A research scholar shall appear before the DSC once in six months to make a presentation of

the progress of his/her work for evaluation and further guidance. The six monthly progress reports shall be submitted by the DSC to the Academic Section before each Semester registration.

v) In case the progress of the research scholar is unsatisfactory, the DSC shall record the reasons for the same and suggest corrective measures. If the research scholar fails to implement these corrective measures, the DSC may recommend with specific reasons for cancellation of the registration of the research scholar.

vi) To conduct registration, enhancement and pre-submission seminars, viva voce.

vii) To act as the examiners in the above seminars and viva voce.

viii) To oversee and advise on all matters related to the Ph.D. work of the scholar.

17.4. Supervisor/co-supervisor

The functions and responsibility of the supervisor/ co-supervisor are:

i) To assign a topic for research to the research scholar in consultation with the scholar.

ii) To recommend the courses to be taken up by the research scholar.

iii) To provide or arrange for facilities to carry out research and supervise the research scholar for the entire research studies.

iv) To monitor the progress of the research scholar.

v) To report to the DSC the performance of the student at the end of each semester.

vi) To recommend a panel of Ph.D. thesis external examiners to DSC.

vii) To forward all applications of the research scholar working under him to the DRPC

Utmost care must be taken by the supervisor(s) with respect to the content, organization and language of the Ph.D. thesis before endorsing it for submission.

17.5. Central Admission Committee (CAC)

17.5.1. Constitution

i) Dean (Academic Research)- Chairman

ii) Chairman of all DRPCs- Members

iii) Associate Dean (Academic Research) - Member

iv) Joint/Deputy Registrar (A&E)- Convener

17.5.2. Functions

To prepare the final list of the selected candidates based on the selection lists prepared by the departments and communicate it to the office of Dean (Academic Research).

17.6. Departmental PhD Programme Coordinator

The Ph.D. Coordinator will be appointed by the HOD on rotation basis, who will be in charge of Ph.D. program in the Department with the following function and responsibilities.

i) To help the department with allotment of Ph.D. students to faculty members.
ii) To maintain a detailed record of departmental Ph.D. students.
iii) To organize Ph.D. admission test and viva voce in each semester as required.
iv) To keep a record of various course works being taken by the Ph.D. students.
v) To monitor that DSC assigned course works are being taken by the Ph.D. students.
vi) To compile the marks of all the course works and submits the same to the Academic Section.
vii) To work in conjunction with the academic section for any relevant issue.
viii) To circulate any departmental Ph.D. related seminar notices as soft copies.
ix) To report to the Academic section, as required, through HOD.
x) Any other function as assigned by the HOD.

18.0 Guidelines for Utilization of Contingency Grant (for attending National/International Conference/Lab visit etc.) [Applicable to Institute Scholars, Category A]

18.1 The financial assistance shall be provided to a research scholar in different heads as follows for attending National/International Conferences within India:

Head	Eligibility	Remarks
Registration Fee	Maximum up to Rs. 5000	On production of fee receipt
Travel	Train(AC III Tier)/AC Bus (by the shortest route)	As per actuals on production of ticket. In case the scholar travels by flight or any other mode, the reimbursement should be actual subjected to an
Local Travel	Auto/Bus	As per actuals subjected to an upper limit of Rs 100 per day on production of bills/self-certification
Lodging	Hostel/Guest House/Hotel for the conference days plus one day each prior to and after the conference days	Actuals subjected to a ceiling of Rs 1000 per day
Per diem	The conference days plus one day each prior to and after the conference days	Rs. 250 per day (No bills required)

18.2 Maximum two conferences can be attended in a calendar year subjected to availability of contingency grant.

18.3 A research scholar will be given the support provided he/she continues to be a student for at least three months after attending the conference.

18.4 The scholar has to obtain an approval from competent authority before attending the conference and should submit settlement of financial assistance granted by the Institute (by listing all the expenses incurred in an orderly manner and duly enclosing all supporting documents) within ten days to the Academic Section.

18.5 In case the purpose of the travel is for data collection/lab visit for conducting experiments, the scholar will be permitted to travel within India, subjected to availability of contingency grant, and the entitlements will be the same as that of conference travel within India.

18.6. List of items, which can be purchased under contingency grant

i) Acquisition of books and documents of relevance to the research topic provided these are not available in the library of the University/Institute.
ii) Chemical/consumable items required for the research work.
iii) Equipment required exclusively for research.
iv) Photographic materials for research or thesis work.
v) Computation charges.
vi) Reprints/ Off- print of research papers.
vii) Stationery and postal charges.
viii) Registration fee for attending conference in India and abroad.
ix) For registration of Ph.D. and submission of thesis.
x) Any other purpose, specially authorized by NIT Durgapur administration.

<u>Contingency grant cannot be used for:</u>

i) Foreign travel or other expenses for visit abroad.
ii) Stationery items such as pen, pencils, folders, file covers, carbon papers etc. and furniture items.
iii) Tuition fees

19.0. Guideline for Composing Ph.D. Thesis

19.0. INTRODUCTION

Purpose

This document, herein after referred to as the Thesis Guide, lists the general and specific requirements governing thesis preparation including guidelines for structuring the contents. For style, structure and presentation of the thesis, students may refer to additional style manuals or reference guides (some of which are listed below) and to the published literature in their respective field of study.

Style Manuals or Reference Guides

i) Michaelson, H.B. *How to Write & Publish Engineering Papers and Reports*. 3rd ed. Phoenix: Oryx Press, 1990.

ii) Turner, R.P. *Technical Report Writing*. 2nd ed. San Francisco: Rinehart Press, 1971.

iii) Turk, C. and Krikman, J. *Effective writing: Improving Scientific, Technical and Business Communication*. 2nd ed. London: E & FN Spon, 1989.

iv) Campbell, W.G., Ballou, S.V. and Slade, C. *Form and Style: Theses, Reports, Term Papers*. 4th ed. Boston: Houghton Mifflin Co., 1974.

v) *MLA Style Manual and Guide to Scholarly Publishing*. 3rd ed. New York: Modern Language Association, 2008.

vi) Sternberg, D. *How to Complete and Survive a Doctoral Dissertation*. New York: St. Martin's Press, 1981.

vii) Day, R.A. and Gastel, B. *How to Write and Publish a Scientific Paper*. Westport: Greenwood Press, 2006.

viii) Booth, W.C., Colomb, G.G. and Williams, J.M. *The Craft of Research*. Chicago: The University of Chicago Press, 2003.

ix) *Publication Manual of the American Psychological Association*. 6th ed. Washington, DC: APA, 2009.

Thesis Submission

To have the thesis examined, two copies of thesis (excluding the copy for the supervisor(s)) are to be submitted to the office of Dean (Academic Research). Besides fulfilling various existing requirements for thesis submission, such as submission of a list of examiners, additional copies of synopsis/abstract, and payment of thesis examination fees (for Ph.D. only), it is to be ensured by the scholar and the respective thesis supervisor (s) that the thesis preparation guidelines have been adhered to.

While submitting the thesis, every student is required to provide a Signed Checklist/ Declaration in the following format to the Dean (Academic Research).

Declaration/ Statement of Thesis Preparation

Thesis title: ……………………………………………………………..

Degree for which the thesis is submitted: ……………………………………

1. Thesis preparation guideline has been followed while preparing the thesis.
2. All specifications regarding thesis format etc. have been followed.
3. The contents of the thesis have been organized based on the guidelines.
4. The thesis has been prepared without resorting to plagiarism.
5. All sources used have been cited appropriately.
6. The thesis has not been submitted elsewhere for a degree.

(**Signature of the student with date**)

Name: __________________________

Registration No.:__________________

Department: _____________________

19.1. THESIS FORMATTING SPECIFICATIONS

19.1.1. Preparation of Manuscript and Copies

19.1.1.1. The thesis needs to be prepared using a standard text processing software and must be printed in black text (color for images, if necessary) using a laser printer or letter quality printer in standard typeface (Times New Roman or Sans Serif font). The font size should also be fixed at 12 in general; exceptions may be there only when it is really required. The medium of writing will be British English.

19.1.1.2. The thesis must be printed or photocopied on both sides of white paper. All copies of thesis pages must be clear, sharp and even, with uniform size and uniformly spaced characters, lines and margins on every page on good quality white paper of 75 gsm or more.

19.1.1.3. Thesis should be free from typographical and grammatical errors.

19.1.2. Size and Margins

19.1.2.1. A4 is the recommended thesis size. The total number of pages should preferably be limited to ~ two hundred (considering both sides of the paper).

19.1.2.2. The top, bottom and right side margins should be 25 mm, whereas the left side margin should be 35 mm for both textual and non-textual (e.g., figures, tables) pages. If one takes print on either side of a page, margin on either right or left side will be different for odd and even pages.

19.1.2.3. Content should not extend beyond the bottom margin except for completing a footnote, last line of chapter/subdivision, or figure/table caption.

19.1.2.4. A sub-head at the bottom of the page should have at least two full lines of content below it. If the texts of the sub-head are too short to allow this, it should begin on the next page.

19.1.2.5. All tables and figures should conform to the same requirements as text. Colour may be used for figures. If tables and figures are large, they may be reduced to the standard size (provided the reduced area is not less than 50% of the original) and/or folded just once to flush with the thesis margin (if the page size does not exceed 250x360 mm).

19.1.2.6. Scholars may choose to submit printed thesis copies either in the standard size (as in 2.2.1) or in a book format that is roughly half of A4. If the book format is adopted for submission, it should be ensured that all textual and illustrative material is distinct and legible. Students should also submit the thesis in soft form (PDF) for storage and archival.

19.1.3. Page Numbering

19.1.3.1. Beginning with the first page of the text in the thesis (Chapter 1), all pages should be numbered consecutively and consistently in Arabic numerals through the appendices.

19.1.3.2. Page numbers prior to Chapter 1 should be in lower case Roman numerals. The title page is considered to be page (i) but the number is not printed.

19.1.3.3. All page numbers should be placed without punctuation in the upper right hand corner, 12 mm from the top edge and with the last digit even with the right hand margin.

19.1.4. Multi-Volume Thesis

A thesis may be in two or more volumes, if required. The volume separation should come at the end(s) of major division(s). The preliminary pages prior to Chapter 1 are contained only in Volume I, except the title page.

19.1.5. Line Spacing

The general text of the manuscript should be in one-and-half spacing. Long tables, quotations, footnotes, multi-line captions and bibliographic entries (references) should be in single spacing, with text size in 11 points.

19.1.6. Tables, Figures and Equations

19.1.6.1. All tables (tabulated data) and figures (charts, graphs, maps, images, diagrams, etc.) should be prepared, wherever possible, on the same paper used to type the text and conform to the specifications outlined earlier. They should be inserted as close to the textual reference as possible.

19.1.6.2. Tables, figures and equations should be numbered sequentially either throughout the thesis or chapter-wise using Arabic numerals. They are referred to in the body of the text capitalizing the first letter of the word and number, as for instance, Table 17, Figure 24, Equation (33), or Table 5.3, Figure 3.11, Equation (4.16), etc.

19.1.6.3. If tables and figures are of only half a page or less, they may appear on the same page as text but separated above and below by double line spacing. Font size for text should be the same as for the general text.
19.1.6.4. Good quality Line Drawings/figures must be drawn using standard software that provides vector rather than bit-map graphics. Figures must be scalable.

19.1.6.5. Images, Photographs, etc. must be scanned in resolution exceeding 200dpi with 256 gray scales for the monochrome images and 24 bit per pixel for the color images.

19.1.7. Binding

The student should submit the copies of the thesis in fully bound form (hard cover). Once the thesis is accepted, it is the student's responsibility to get it properly hard bound before submitting the required number of copies with the Academic Research Section / Central Library and the Department and Supervisors concerned. The front cover of the bound copy should be the same as the title page of the thesis. The front cover should have printing on the side to include the author's name, abbreviated thesis title (optional), degree, department, and the year. The color of the binding cover should be maroon for Ph.D. with golden color writings on it).

19.2. GUIDELINES FOR STRUCTURING THE CONTENTS

19.2.1. Sequence of Contents

The following sequence for the thesis organization should be followed:

(i) Preliminaries	Title Page	As per the format given at the end of the guidelines.
	Certificate	
	Abstract/Synopsis	
	Acknowledgement and/ or Dedication (if included)	
	Table of Contents	
	List of Figures, Tables, Illustrations,	
	Symbols, etc. (wherever applicable)	
(ii) Text of Thesis	Introduction	
	The body of the thesis	
	Summary and conclusions	
(iii) Reference Material: List of References, Bibliography (where included)		
(iv) Appendices, if included		
(v) Index, if included		

All the Chapter headings are centered (without punctuation) 25mm down the top edge of the page. The subsequent type-setting begins three spaces below the heading.

19.2.2. Preliminaries

19.3.2.1. A Ph.D. thesis should contain an abstract/synopsis typically not exceeding 1000 words (about four pages) in one-and-half spacing.

19.2.2.2. Ph.D. students shall also separately submit three copies of the synopsis/abstract.

19.2.2.3. Every student should submit two copies of abstract/synopsis not exceeding 250 words (one page) for record keeping in the Central Library.

19.2.2.4. A synopsis/ abstract shall be printed in one-and-half space with the heading “SYNOPSIS/ ABSTRACT” in uppercase followed by certain preliminary information and the text. For textual matter, refer to the suggested format which is placed at the end of the Thesis Guide.

19.2.2.5. Synopsis/Abstract should be self-complete and contain no citations for which the thesis has to be referred.

19.2.3. Table of contents

19.2.3.1. The table of contents lists all material that follows it. No preceding material is listed. Chapter titles, sections, first and second order sub-divisions, etc. must be listed in it.

19.2.3.2. Tables, figures, nomenclature, if used in the thesis, are listed under separate headings.

19.2.4. The Text of the Thesis

19.2.4.1. Introduction

Introduction may be the first chapter. It should contain a brief statement of the problem investigated. It should outline the scope, aim, general character of the research and the reasons for the student's interest in the problem.

19.2.4.2. The body of Thesis

This is the substance of the dissertation inclusive of all divisions, subdivisions, tables, figures, etc.

19.2.4.3. Summary and conclusions

If required, these are given as the last major division (chapter) of the text. A further and final subdivision titled "Scope for Further Work" may follow.

19.2.4.4. Reference material

The list of references should appear as a consolidated list with references listed either alphabetically or sequentially as they appear in the text of the thesis. If pertinent works have been consulted but not specifically cited, they should be listed as Bibliography or General References. Spacing and font size should be consistent inside a single reference, and there should be a single spacing between two different references (see Section 2.5).

Reference Format

- For referencing an article in a scientific journal the suggested format should contain the following information: authors, title, name of journal, volume number, page numbers and year.
- For referencing an article published in a book, the suggested format should contain, authors, the title of the book, editors, publisher, year, page number of the article in the book being referred to.
- For referencing a thesis the suggested format should contain, author, the title of thesis, name of the institute where thesis was submitted or awarded, and year.

- A few examples of formats of references are given below and the student should be consistent in following the style.

Journals

H.E. Exner, “Physical and Chemical Nature of Cemented Carbides,” *International Metals Review*, 1979, v. 24, pp. 149-173.

G.E. Spriggs, “The Importance of Atmosphere Control in Hard Metal Production,” *Powder Metallurgy*, 1970, v. 13, n. 26, pp. 369-393.

Conference Proceedings

H.F. Fischmeister, “Development and Present Status of the Science and Technology of Hard Materials,” Science of Hard Materials, R.K. Viswanadham, D.J. Rowcliffe, and J. Gurland (eds.), Plenum Press, New York, NY, USA, 1982, pp. 1-45.

W.H. Baek, M.H. Hong, S. Lee, and D.T. Chung, “A Study on the Shear Localization Behavior of Tungsten Heavy Alloy,” Tungsten and Refractory Metals 2, A. Bose and R.J. Dowding (eds.), Metal Powder Industries Federation, Princeton, NJ, USA, 1995, pp. 463-471.

Books

R.M. German, Powder Injection Molding, Metal Powder Industries Federation, Princeton, NJ, USA, 1990.

Thesis

J.L. Johnson, “Densification, Microstructural Evolution, and Thermal Properties of Liquid Phase Sintered Composites,” Ph.D. Thesis, The Pennsylvania State University, University Park, PA, USA, 1994.

Technical Reports

E.G. Zukas, P.S.Z. Rogers, and R.S. Rogers, “Experimental Evidence for Spheroid Growth Mechanisms in the Liquid Phase Sintered Tungsten Based Composites,” Informal Report: Los Alamos Scientific laboratory, USA, 1976, pp. 1-35.

Patents

V. Oenning and I. S. R. Clark, U. S. Patent No. 4988386, 1991.

Journals in Non-English Language

L. Weihong and T. Xiuren, “Tungsten Matrix in Cu-W Contact Materials by Impregnation Process,” *Powder Metallurgy Technology*, 1988, v. 6, n. 8, pp. 1-4. (in Chinese)

19.2.4.5. **Appendix or Appendices**

Supplementary illustrative material, original data, and quotations too lengthy for inclusion in the text or which is not immediately essential to an understanding of the subject can be presented in Appendix or Appendices (as Appendix A , Appendix B, etc.).

Each appendix with its title should be listed separately in the table of contents. Likewise, tables and figures contained in the Appendices are to be included in the lists of tables and figures, respectively.

19.3. CONCLUDING REMARKS

This Thesis Guide lists only the basic requirements for preparing the thesis. Over and above the aforementioned points, a thesis should be reader-friendly in both its appearance and presentation. Several aspects of thesis preparation, particularly style of writing and presentation, have not been discussed in great detail. The student should follow appropriate ideas from standard literature of his/her area of research, and adopt a uniform style and format throughout the thesis, such as in the structural divisions/subdivisions of the thesis, in the mode of citing references and footnotes in the text, in using dimensions, units and notations, and in preparing tables and figures, etc.

Title of the Thesis

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

Name of the student
(Regn. No. ………….)

Under the Supervision
of
Supervisor Name(s)
(Name of the Department)

DEPARTMENT OF -----------------------------------
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
WEST BENGAL – 713209
INDIA

Month, Year

Declaration/ Statement of Thesis Preparation

Thesis title: ……………………………………………………………..

Degree for which the thesis is submitted: ……………………………………

- ✓ Thesis preparation guideline has been followed while preparing the thesis.
- ✓ All specifications regarding thesis format etc. have been followed.
- ✓ The contents of the thesis have been organized based on the guidelines.
- ✓ The thesis has been prepared without resorting to plagiarism.
- ✓ All sources used have been cited appropriately.
- ✓ The thesis has not been submitted elsewhere for a degree.

(**Signature of the student with date**)

Name: ___________________________

Registration No.:__________________

Department: **______________________**

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Department/Centre:

M. G. Avenue, Durgapur, 713209, West Bengal, India

CERTIFICATE

It is certified that the work contained in the thesis entitled "**Title of the Thesis"** has been carried out by me [**"Name of the Student, Roll No. & Regn. No."]** under the guidance of "**name of the supervisor(s) at (Name of the Dept. & Institute)**. The data reported herein is original and that this work has not been submitted elsewhere for any other Degree or Diploma.

(**Signature of Cand**idate)
Name of the candidate
Place…………………………..:
Date…………………………..:

This is to certify that the above declaration is true.

(**Signature of Supervisor(s)**)

Name of the Supervisor(s)
Place: ……………………………..
Date……………………………….:

Acknowledgements

Body of the text.

Date: xx/xx/xxxx

Name of the Student
Regn. No.:__________________
Department:________________
National Institute of Technology Durgapur
West Bengal, 713209, India

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List of Figures

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SALIENT DOCUMENTS TO BE SUBMITTED DURING Ph.D. PROGRAMME
(Please follow the current checklist/circular as notified time to time)

A. Documents required at the time of Ph.D. admission:

1. Marks sheets/Grade cards of the secondary, higher secondary board and other university examinations.
2. Certificate/provisional certificate of all the examinations.
3. Proof of date of birth.
4. Migration Certificate (Original).
5. Community certificates (SC/ST) from a competent authority, if applicable.
6. Valid community certificate in case of OBC/EWS candidates from a competent authority, if applicable.
7. Valid PwD certificate from competent authority, if applicable.
8. NET/GATE/CSIR-UGC/any other qualifying examination certificates as applicable.
9. No Objection Certificate from the employer of the student, if applicable.
10. Sponsorship certificate from the employer of the student, if applicable.
11. Two recent passport size color photograph.

B. Documents required within ONE/TWO MONTH of admission:

1. Doctoral Scrutiny Committee (DSC) signed by all members.
2. Courses to be taken by a Ph.D. student.
3. Willingness certificate of co-supervisor, if applicable.
4. No Objection Certificate from the employer of the co-supervisor, if applicable.
5. Curriculum vitae of the co-supervisor, if applicable.

C. Documents required at the time of every semester registration till submission of thesis:

1. Semester registration fee payment proof.
2. Duly filled in Semester registration form.

D. Documents required at the time of Ph.D. registration (within FIFTH semester of admission):

1. Duly filled in Application form.
2. A write-up/report of work done and detailed plan of work (within 10 pages).
3. Registration fees payment proof.
4. Copies of the grade cards of the course works done.

E. Documents required at the time of Ph.D. pre-synopsis submission:

1. ONE copy of the synopsis (Maximum 3000 words within 10 pages), along with a soft copy of the same.
2. Copies of research papers published.
3. Evaluation Report on Pre-Submission Seminar for Ph.D. Thesis.

F. Documents required at the time of Ph.D. thesis submission for examination:

1. Document of Thesis submission fees payment.
2. List of Examiners (India & Abroad) for Evaluation of Ph.D. Thesis (Confidential, in sealed cover).
3. TWO copies of Ph.D. Thesis (hard-bound; maximum ~200 pages including both sides printed), along with a softcopy of the same.
4. Any other document as may be required by the Academic Section at the time of submission.

G. Documents required at the time of Ph.D. thesis defense:

1. Three + nos. of supervisor (s) copies of Ph.D. thesis (hard-bound), along with a soft copy of the same.
2. A CD/DVD containing all documents submitted during pre-synopsis seminar, Ph.D. thesis submission and Ph.D. defense are to be submitted.
3. Any other document as may be required by the Department / Academic Research Section.

20.0. FORMATS OF DIFFERENT FORMS IN RELATION TO Ph.D. STUDIES

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Office of the Dean (Academic Research)

Mahatma Gandhi Avenue, Durgapur-713209,
West Bengal, INDIA

Formats of Different Forms in Relation to Ph.D. Studies

(ALL CONFIDENTIAL DOCUMENTS IN PRINTED FORMATS ARE TO BE SUBMITTED THROUGH DSC & THE OFFICE OF HODS/CENTERS IN SEALED ENVELOPE ONLY)

FORM NO.	DESCRIPTION
1	Information Sheet
2	Ph.D. Semester Registration Form
3	Doctoral Scrutiny Committee (DSC) (The FORM 3 can be used for the submission of revised DSC, if required)
4	Courses to be Undertaken by the Scholar During Doctoral Programme
5	Registration Form for Ph.D. Programme
6	Evaluation Report for Enhancement of Fellowship for Ph.D. Degree
7	Evaluation Report on Pre-Submission Seminar for Ph.D. Thesis
8	Ph.D. Thesis Submission Form
9	Ph.D. Thesis Re-Submission Form
10	List of Examiners (Summary) for Evaluation of Ph.D. Thesis
11	List of Examiners (India- Five) for Evaluation of Ph.D. Thesis
12	List of Examiners (Abroad-Five) for Evaluation of Ph.D. Thesis
13	Ph.D. Thesis Evaluation Report
14	Report on Viva-Voce & Defense for Ph.D. Degree
15	Formation of the Committee for Ph.D Defense by Video Conferencing
16	Format of Willingness Certificate from the External Faculty Member Who Wishes to Become Co-supervisor of a Ph.D. Student at NIT Durgapur
17	Format of No Objection Certificate from The Employer to Become Co-supervisor of a Ph.D. Student at NIT Durgapur
18.	Faculty Information Sheet

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 1

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA **INFORMATION SHEET (PAIS)**

(To be submitted at the time of admission)

One passport size Photograph (color)

1. Name of the Scholar (Block Capital Letters):

2. Father's Name:

3. Roll No. (To be given after the admission):

4. Name of the Department/Centre:

5. Category of Admission (Category A, B, C, etc.):

6. (a) Gender (Male/Female/Transgender): **(b) Blood Group:**

7. Marital Status (Married/Single):

8. Identity Card Name and Number:

9. Category (OPEN/ OBC-NCL/SC/ST/EWS):

10. PwD (Yes/No):

11. (a) Nationality (Indian/Foreign):

(b) In case of Foreigner - Passport No: **Visa No:**

12. (a) NET/GATE (Score):

a.1. NET: **a. 2. GATE:**

(b) Year of Qualifying/ Period of NET/ GATE:

(c) Rank (GATE/NET etc.):

(d) Branch/Discipline:

13. Complete Postal Address with PIN Code:

14. Telephone/Mobile No.:

15. E- Mail ID:

16. Academic Qualification: (Starting from Madhyamik (10^{th}) or Equivalent Examination)

Name of Exam. Passed	Name of the School/College/ Institute/University	Year of Passing	Discipline/ Specialization	Percentage of Marks /CGPA

17. If employed, [Name of the employer, nature of work, total experience, copy of the Sponsorship/No-Objection certificate from the organization/Employer must be enclosed]:

(a) Name of the Employer:
(b) Nature of Service/work:
(c) Total years of Experience:
(d) List of Enclosures (Sponsorship/No-Objection certificate from the organization/Employer):

18. Full signature of the Scholar with Date:

Forwarded with comments by Head of the Dept./Centre Coordinator:
Signature of the Head with date:
Department of ---

Asso. Dean (Academic Research) / Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 2

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

Ph.D. SEMESTER REGISTRATION FORM

(SEMESTER 1 TO SEMESTER 10: PSRF-1 TO PSRF-10)

(To be submitted at the beginning of each semester on payment of the registration fee)

---

1. Name of the Scholar:

2. Roll No.:

3. Registration No. (after Ph. D. registration):

4. Department / Branch:

5. Institute Fees paid (Attach self-attested copy of payment receipt): (a) Amount (Rs.):

(b) Mode of payment details (Online/Offline):

(c) Transaction Id/ Receipt No. /Reference No.:

(d) Date of Payment:

6. Semester No. (Sem. 1, Sem. 2 etc.):

7. Academic Session:

8. Courses to be taken in this Semester:

Sl. No.	Course Code	Name of the subject(s)	Signature of the faculty/(s) offering the Course
1.			
2.			
3.			
4.			

9. Progress (within -50 words) made by the scholar during the LAST semester (Detailed progress report may be attached as additional sheet):

10. Full Signature of the Scholar with date:

11. (a) The Progress made by the scholar is Satisfactory? (Filled in by the supervisor): **YES / NO**

(b) Is the scholar eligible for the semester registration? (Filled in by the supervisor): **YES / NO**

Signature of Supervisor with date:

Signature of the Chairperson, DSC

Asso. Dean (Academic Research) / Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM -3

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA **DOCTORAL SCRUTINY COMMITTEE (DSC)**

(To be submitted within 15 days after taking admission in the programme)

The DSC is here by constituted for the doctoral study of the following scholar:

1. Name of the Scholar:

2. Roll No.:

3. Date of Admission /Enrollment:

4. Name of the Department:

Sl. No.	Member / Chairperson	Full Name	Dept./ Organization	Signature
1.	**CHAIRPERSON** (DRPC / Chairperson DSC Nominated)	HOD (ex-officio / Chairperson DSC Nominated)		
2.	**MEMBER** Concerned supervisor(s)for the research scholar	(i)	(i)	(i)
		(ii)	(ii)	(ii)
3.	**MEMBER** Two faculty members of the Department having Ph.D. degree [if not available, faculty member(s) from other Department(s) with Ph.D degree]	(i)	(i)	(i)
		(ii)	(ii)	(ii)
4	**MEMBER** One non-departmental faculty member of the Institute having Ph.D degree (Nominated by the Senate)			

IT IS CERTIFIED THAT AT PRESENT ANY OF THE SUPERVISORS IS NOT SUPERVISING MORE THAN 06 (SIX) Ph.D. SCHOLARS.

Signature of CHAIRPERSON, DSC:

Date:

Asso. Dean (Academic Research) / Dean (Academic Research)

[*Please attach the CV, consent letter and NOC of the employer from the supervisor, if s/he is not a faculty member of NIT Durgapur. NOC is not required if the supervisor belongs to an institution/organization having MoU with NIT Durgapur*]

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 4

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA **COURSES TO BE UNDERTAKEN BY THE SCHOLAR DURING DOCTORAL PROGRAMME (To be submitted within TWO months of admission to the programme)**

---

1. Name of the Scholar:

2. Roll No.:

3. Date of Admission /Enrollment:

4. Department / Branch:

5. Coursework assigned by the DSC:

Sl. No.	Course Code	Name of the subject(s)	Signature of the Faculty/(s) offering the Course
1.			
2.			
3.			
4.			
5.			

6. Name and Signature of the DSC Members:

Sl. No.	Name of the DSC member	Role	Signature with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	

CHAIRPERSON, DSC

Asso. Dean (Academic Research) / Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 5

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA **Registration Form for Ph.D. Programme**

(To be submitted on completion of course work and pre-registration seminar)

---

1. Name of the Scholar:

2. Roll No.:

3. Date of Admission /Enrollment:

4. Department / Branch:

5. Father's Name:

6. Complete Postal Address:

7. (a) Category of Admission: **(b) Change of Category, if any (Category A, B, C, etc.):**

8. Qualifying Degree of the Scholar with the Date of obtaining the Degree:

9. Course Works (Total Credit): (a) Assigned by DSC __________(b) Requirement as per PhD Regulations:________

(c) Completed: (enclose copy of the grade cards)__________.

Sl. No.	Course Code	Course Name	Grade Obtained	Date of Completion

9. Proposed area of Research [Two copies of the brief Outline of Proposed Research Work, signed by the Scholar & Supervisor (s) are to be submitted along with this application]:

10. Title of the Thesis:

11. Nos. of Publication (if any):

12. Date of Pre-registration Seminar:

Recommendation*: **<u>Recommendation of DSC for Registration for Ph.D. Programme</u>**

Sl. No.	**Name of the DSC Member**	**Role**	**Signature with date**
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	

Registration No:

CHAIRPERSON, DSC

Approved in the RAC, dated:

Approved in the Senate dated:

Asso. Dean (Academic Research) / Dean (Academic Research)

*[*Sample: The applicant has fulfilled all the requirements for registration to PhD Programme of the Institute and may be permitted for registration to the PhD Programme or as applicable].*

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 6

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

EVALUATION REPORT FOR ENHANCEMENT OF FELLOWSHIP FOR Ph.D. DEGREE

(After Two Years of Admission)

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission/Enrollment:

5. Registration No.:

6. Date of Registration:

7. Date of Seminar

8. Title of the Thesis:

9. Details of Publications in Journals/Conferences, if any (Published/Accepted/Communicated):
(a) Journals:

(b) Conferences:

10. Recommendation:

(a) The Progress made by the scholar is Satisfactory? **YES / NO**

(b) The DSC **RECOMMENDS/DOES NOT RECOMMEND** for an enhancement in fellowship:

(c) The Effective date of Enhancement in Fellowship (date of successful completion of the seminar):

11. Name and Signature of the DSC Members:

Sl. No.	Name of the DSC member	Role	Signature with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	

CHAIRPERSON, DSC

Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM -7

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA **EVALUATION REPORT ON PRE-SUBMISSION SEMINAR FOR Ph.D. THESIS**

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission /Enrollment:

5. Registration No.:

6. Date of Registration:

7. Date of Pre-submission Seminar

8. Title of the Thesis (FINAL):

9. Recommendation (Write the comments):

10. Publication Details and the comments of the DSC:

(a) **Nos.** of Research papers published/accepted for publication in Journals (SCI/SSCI/AHCI/Non-paid Scopus/ Web of Science)- Attach list of publications and the first pages of the papers): **SCI:____SSCI: ______AHCI:__________ Non-paid Scopus:___________ Web of Science:___________**	**Total =**
(b) Nos. of Research Papers presented in Conferences/Seminars (Attach certificate of presentations and the first pages of the papers)	
Comment*:	

11. Name and Signature of the DSC Members:

Sl. No.	Name of the DSC members	Role	Signature of the DSC members with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	

CHAIRPERSON, DSC

Dean (Academic Research)

*[***Sample Comment:*** The DSC members have scrutinized the publications and research work of the candidate and those are found to be Sufficient/ Not sufficient & Satisfactory / Not satisfactory as per Ph.D. regulations of the Institute.]*

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 8

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

Ph.D. THESIS SUBMISISON FORM

(Please Refer to the Checklist/Notifications for Submission of Other Required Documents)

[*The filled up soft copies in pdf format (with Signature) must be sent from the Institute email address of Chairperson, DSC / Supervisor to Dean (Academic Research) only*].

---

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission/Enrollment:

5. Registration No.:

6. Date of Registration:

7. Date of Submission of Thesis:

8. Title of the Thesis:

9. Thesis submission fees (Enclose relevant documents as proof):

(a) Amount (Rs):

(b) Transaction details:

(c) Date of payment of fees:

10. Details of semester registration fees due (As applicable):

11. Recommendation of DSC:

Sl. No.	Name of the DSC members	Role	Signature of the DSC members with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	

CHAIRPERSON, DSC

Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 9

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

Ph.D. THESIS RE-SUBMISISON FORM

(Please refer to the checklist for submission of other required documents)

[*The filled up soft copy in pdf format (with Signature) must be sent from the Institute email address of Chairperson, DSC/Supervisor to Dean (AR)/Asso. Dean (AR) only*].

---

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission/Enrollment:

5. Registration No.:

6. Date of Registration:

7. Earlier Date of Submission of Thesis:

8. Title of the Thesis:

9. Result of Plagiarized check for revised PhD thesis (maximum permissible match upto 20% excluding Publications of the research scholar and corresponding supervisor (s)**):   %**

10. Recommendation/Decision of the Indian Examiner on original thesis:

11. Decision of the Foreign Examiner on original thesis (To be revised and sent back/ Not recommended)

12. Date of communication of the decision to the supervisors:

13. Details of thesis Re-submission fees (Enclose relevant documents as proof):
(i) Amount (Rs): **(ii) Transaction details:** **(iii) Date of fee payment:**

14. (a) Date of payment of last semester registration fees:
(b) Details of payment of semester registration fees upto current semester (As applicable):
(i) Amount (Rs): **(ii) Transaction details:** **(iii) Date of fee payment:**

15. Recommendation with Comments of DSC:

16. Name and Signature of the DSC Members:

Sl. No.	Name of the DSC member	Role	Signature with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	

CHAIRPERSON, DSC

Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 10

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

LIST OF EXAMINERS (SUMMARY) FOR EVALUATION OF Ph.D. THESIS

[*The filled up soft copy in pdf format (with Signature) must be sent from the Institute email address of Chairperson, DSC / Supervisor to Dean (AR) / Asso. Dean (AR) only*].

All confidential documents in printed format are to be submitted through the office of HODs/Centers in sealed envelope only

---

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission /Enrollment:

5. Registration No.:

6. Date of Registration:

7. Date of Submission of Thesis:

8. Title of the Thesis:

9. Total No. of research papers published/accepted for publication in SCI/SSCI/AHCI/Scopus/Web of Sc. Journals:

SCI: **SSCI:** **AHCI:** **Scopus:** **Web of Science:**

10. No. of papers presented in conferences/seminars (enclosed the presentation certificate):

11. Result of Plagiarized check for PhD thesis (maximum permissible match upto 20% excluding Publications of the research scholar and corresponding supervisor (s)**):** **%**

12. Courses completed as per requirement of the Ph.D. regulations: (Yes/No)

13. All other necessary documents have been submitted to Academic Research Section: (Yes/No)

14. Thesis Submission Fes (Enclose relevant documents as proof):

(a) Amount (Rs): **(b) Transaction details:** **(c) Date of fee payment:**

Sl. No.	Name of the DSC member	Role	Signature with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	
6.			**Chairperson, DSC**

Dean (Academic Research)

DIRECTOR

FORM - 11

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

LIST OF EXAMINERS (INDIA- FIVE) FOR EVALUATION OF Ph.D. THESIS

[*The filled up soft copy in word format (without Signature) and pdf format (with Signature) must be sent from the Institute email address of Chairperson, DSC/Supervisor to Dean (AR)/Asso. Dean (AR) only*]. *All confidential documents in printed format are to be submitted through the office of HODs/Centers in sealed envelope only.*

1. Name of the Scholar:

2. Registration No.:

3. Title of the Thesis:

Sl. No.	Contact Details	Nos. of Times the Examiner Examined Thesis Supervised by the Present Supervisors Earlier
1	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with PIN code	
	Contact Phone No.:	
	E-mail	
	Webpage	
2	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with PIN code	
	Contact Phone No.:	
	E-mail	
	Webpage	
3	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with PIN code	
	Contact Phone No.:	
	E-mail	
	Webpage	
4	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with PIN code	
	Contact Phone No.:	
	E-mail	
	Webpage	
5	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with PIN code	
	Contact Phone No.:	
	E-mail	
	Webpage	

It is certified that the above persons have not acted as author/co-author of the research scholar in any of her/his publications (Journals /Conferences / Patent) at any time. It is also certified that the supervisor(s) of the thesis, do not have any potential conflict of interest with the above suggested examiners/persons.

Signature of the Supervisor /(s) & DSC members

Sl. No.	Name of the DSC Member	Role	Signature with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	
6.	**CHAIRPERSON, DSC**		

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM -12

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

LIST OF EXAMINERS (ABROAD-FIVE) FOR EVALUATION OF Ph.D. THESIS

[*The filled up soft copies in word format (without Signature) and pdf format (with Signature) must be sent from the Institute email address of Chairperson, DSC to Dean (Academic Research) only*]. *All confidential documents in printed format are to be submitted through the office of HODs/Centers in sealed envelope only.*

1. Name of the Scholar:
2. Registration No.:
3. Title of the Thesis:

Sl. No.	Contact Details	No. of times the examiner examined thesis supervised by the present supervisors earlier
1	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with Box No. St. No. etc.	
	Contact Phone No.:	
	E-mail	
	Webpage	
2	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with Box No. St. No. etc.	
	Contact Phone No.:	
	E-mail	
	Webpage	
3	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with Box No. St. No. etc.	
	Contact Phone No.:	
	E-mail	
	Webpage	
4	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with Box No. St. No. etc.	
	Contact Phone No.:	
	E-mail	
	Webpage	
5	Name	
	Designation	
	Department	
	Name of the organization	
	Complete postal address with Box No. St. No. etc.	
	Contact Phone No.:	
	E-mail	
	Webpage	

It is certified that the above persons have not acted as author/co-author of the research scholar in any of her/his publications (Journals /Conferences / Patent) at any time. It is also certified that the supervisor(s) of the thesis, do not have any potential conflict of interest with the above suggested examiners/persons.

Signature of the Supervisor /(s) & DSC members

Sl. No.	Name of the DSC Member	Role	Signature with date
1.		Supervisor	
2.		Supervisor	
3.		Member	
4.		Member	
5.		Member	
6.			**CHAIRPERSON, DSC**

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 13

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

[ON OFFICIAL LETTER HEAD]

Ph.D. THESIS EVALUATION REPORT

Submitted to

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR, INDIA

Please Fill up All the Fields under Sections- A, B, and C

A. DETAILS OF THE EXAMINERS	
Name of the Examiner:	
Designation:	
Official Address:	
E–mail ID:	
Telephone/Fax:	
B. DETAILS OF THE SCHOLAR/STUDENTS	
Name of the Scholar	
Registration No. of the Scholar:	
Title of the Thesis:	

C. DECISION ON THE AWARD OF Ph.D. DEGREE: (**Please submit the detailed report on the thesis separately*).	
RECOMMENDATION TERMS	**RECOMMENDATION** (Please Specify /Write Your Recommendation by Choosing any One From the List of Recommendation Terms)
(i) Recommended. (ii) Not recommended. (iii) To be revised and sent back to the examiner. (iv) To be revised but need not be sent back to the examiner.	______________________________

The undersigned declare that there is no Conflict of Interest.

Signature of the Examiner with official Seal

Place:

Date:

[ON OFFICIAL LETTER HEAD]

Ph.D THESIS EVALUATION REPORT
Submitted To
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR, INDIA

DETAILED REPORT OF THE THESIS (*at least 500 words*)

(Please assess the strength and weakness of the Ph.D. thesis in detail and indicate corrections /clarification /scope for improvement, if any, in a separate attachment)

Signature of the Examiner with official Seal

Place:

Date:

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 14

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

REPORT ON VIVA-VOCE & DEFENSE FOR Ph.D. DEGREE

[*The filled up soft copy in pdf format (with Signature) must be sent from the Institute email address of Chairperson, DSC to Dean (Academic Research) only*].

---

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission /Enrollment:

5. Registration No.:

6. Date of Registration:

7. Date of Submission of Thesis:

8. Title of the Thesis:

9. Date of Defense Seminar Presentation & Viva-Voce:

10. Total No. of papers published/accepted for publication in SCI/SSCI/AHCI/Scopus/Web of Sc. journals:
SCI: SSCI: AHCI: Scopus: Web of Science:

11. No. of papers presented in conferences/seminars (enclosed the presentation certificate):

12. Whether the modification/Correction (if any) as suggested by External Examiners have been incorporated and modified version of the thesis submitted:

13. Recommendation:
(A) Performance (Please attach additional sheet for any comments, if required):

(B) B1. Degree, if recommended, to be awarded (Yes/No):
B2. Ph.D., Department of_________________________________.

14. Name and Signature of Members of the Board Examiners (Defense & Viva-Voce):

Sl. No.	Name of the DSC members	Role	Signature of the DSC members with date
1.		Supervisor /(s)	
2.		Supervisor /(s)	
3.		Member	
4.		Member	
5.		Member	
6.		**External Examiner**	
6.	**CHAIRPERSON, DSC with Seal**		

Dean (Academic Research)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM - 15

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

FORMATION OF THE COMMITTEE FOR Ph.D DEFENSE BY VIDEO CONFERENCING

[*The filled up soft copy in word format must be sent from the Institute email address of Chairman, DSC /Supervisor to Dean (Academic Research) only*].

---

1. Name of the Scholar:

2. Department / Branch:

3. Roll No.:

4. Date of Admission /Enrollment:

5. Registration No.:

6. Date of Registration:

7. E-mail:

8. Date of Submission of Thesis:

9. Title of the Thesis:

10. Date of Submission of the Compliance report:

Supervisor(s):

Name	Department	E-mail address

Members of the DSC:

Name	Department	E-mail address

Chairman DSC:

Name	Department	E-mail address

External Examiner (For Ph.D Defense Only):

Name	Affiliation	E-mail address

Additional attendee (at least three): (Faculty/Research scholar from the same or other Department)

Name	Affiliation and Department	E-mail address

(Full Signature of the Supervisor(s) with date)

(Full Signature of the CHAIRPERSON, DSC with date)

(TO BE PRINTED ON THE LETTER HEAD) **FORM - 16**

Format of Willingness Certificate from the External Faculty Member Who Wishes to Become Co-supervisor of a Ph.D Student at NIT Durgapur

To whomsoever it may concern

This is to state that I, Prof./ Dr. (Full Name) ………………………………………………………………………

have been working as a (Designation) ………………………………………………………………………………

in the Department of (Name of Department) …………………………………………………………… in…………………………………………………………. (Name of Institute/university/organization).

I would like to express that I want to become a co-supervisor of the Ph.D. scholar named…………… Roll No.: …………………………… and Registration No……………………………………… of the Department of ……………………………………………………..of National Institute of Technology Durgapur.

I shall guide the student throughout his / her tenure as a Ph.D. student, as and when required following the Ph.D. rules & regulations of National Institute of Technology Durgapur.

Thanking you

Yours sincerely,

Signature of the External Faculty Member

Official Seal & Date:

(TO BE PRINTED ON THE LETTER HEAD) **FORM - 17**

Format of No Objection Certificate from the Employer to Become Co-Supervisor of a Ph.D. Student at NIT Durgapur

To whomsoever it may concern

This is to certify that Prof./ Dr. (Full Name) ____

has been working as a (Designation) ____
in the Department of (Name of Department) ____________________ in (Name of Institute/University/Organization, Address)____
for ________ Yrs., since ____________(XX XX XXXX).

We have no objection, if he/she now becomes a co-supervisor of the Ph.D. student named ………………………………………………………………Roll No.:…………… & Registration No.:……………………………………… of the Department …………………………………………………………………………of National Institute of Technology Durgapur.

He/she will do the needful for the said student as required, without affecting his/her regular assignments of this Institute/University/Organization.

Thanking you
Yours sincerely,

(**Full Signature Head of the Institute/University/Organization**)
Date:

Official Seal

FORM - 18

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

FACULTY INFORMATION SHEET

[This is to be submitted by the supervisor (s) concerned along with the Form 3 during the formation of DSC]

Name of the Faculty			
Designation		**Nos. of Ph.D. Students Supervised**	
Department		**Nos. of Ph. D. Students Supervising**	

TABLE - 1

Details of Ph.D. Students (SUPERVISED)

Sl. No.	Name of the Scholar	Name of Supervisor (s)	Year of Degree Award	Name of the Institute (Degree Awarded)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

TABLE – 2

DETAILS OF Ph.D. STUDENTS (SUPERVISING – AT NIT DURGAPUR)

Sl. No.	Name of the Scholar	Roll No.	Reg. No.	Name of Supervisor (s)	Remarks (Ongoing / Submitted)
1.					
2.					
3.					
4.					
5.					
6.					

TABLE - 3

DETAILS OF Ph.D. STUDENTS (SUPERVISING - OUTSIDE NIT DURGAPUR)

Sl. No.	Name of the Scholar	Roll No.	Reg. No.	Name of Supervisor (s)	Name of the Institute where the scholar is Admitted / Registered
1.					
2.					
3.					

Additional sheets may be used for **TABLE** - 1, **TABLE - 2** and **TABLE - 3**

The information as stated above is true and correct to the best of my knowledge.

Full Signature of the Faculty Member:
Date:

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

Office of the Dean (Academic Research)

List of Documents to be Submitted for PhD Activities

1. LIST OF DOCUMENTS TO BE SUBMITTED AFTER PhD PRE- REGISTRATION SEMINAR (ALL DOCUMENTS TO BE SUBMITTED TOGETHER)

Sl. No.	List of the Documents (to be Submitted to the Office of the Dean (AR)- in Printed Format)	Remarks
1.	Registration Seminar Notice	In original
2.	Registration Seminar Report **(FORM-5)**	In original
3.	Migration Certificate in original	If, not submitted during the Admission
4.	Synopsis (within 10-15 pages)	One copy (first and last page duly signed by the supervisor and all the pages by the scholar)
5.	Grade Cards of the PhD Course Works Done	Xerox copies (Duly signed by the scholar)
6.	Last Semester Registration Fee Payment Receipt	Xerox copy (Duly signed by the scholar)
7.	DSC Formation Document **(FORM-3)**	Xerox copy (Duly signed by the-supervisor)
8.	**Rs. 2000/- Registration Fee Payment Receipt ****for those who got admitted before 2019** **(Canara Bank, NIT Durgapur. A/C No. 8569101000352, IFSC: CNRB0008569)**	In original or **online payment receipt should be verified by the Bank**
DEADLINE OF SUBMISSION OF DOCUMENTS: Within 5 Working Days from the Date of Seminar.		

2. LIST OF DOCUMENTS TO BE SUBMITTED AFTER PhD ENHANCEMENT SEMINAR (ALL DOCUMENTS TO BE SUBMITTED TOGETHER)

Sl. No.	List of the Documents (to be Submitted to the Office of the Dean (AR)- in Printed Format)	Remarks
1.	Fellowship Enhancement Seminar Notice	In original
2.	Fellowship Enhancement Seminar Evaluation Report **(FORM-6)**	In original
3.	Progress Report (within 10-15 pages)	One copy (first and last page duly signed by the supervisor and all the pages by the scholar)
4.	Grade Cards of the PhD Course Works Done	Xerox copies (Duly signed by the scholar)
5.	Last Semester Registration Fee Payment Receipt	Xerox copy (Duly signed by the scholar)
6.	DSC Formation Document **(FORM-3)**	Xerox copy (Duly signed by the-supervisor)
7.	Registration Certificate	Xerox copy (Duly signed by the-supervisor)
DEADLINE OF SUBMISSION OF DOCUMENTS: Within 5 Working Days from the Date of Seminar.		

RK

3. LIST OF DOCUMENTS TO BE SUBMITTED AFTER PhD PRE-SYNOPSIS SUBMISSION SEMINAR (ALL DOCUMENTS TO BE SUBMITTED TOGETHER)

Sl. No.	List of the Documents (to be Submitted to the Office of the Dean (AR)- in Printed Format)	Remarks
1.	Pre-Synopsis Submission Seminar Notice	In original
2.	Pre-Synopsis Submission Seminar Report **(FORM-7)**	In original
3.	Synopsis (within 15-20 pages)	One copy (first and last page duly signed by the supervisor and all the pages by the scholar)
4.	Last Semester Registration Fee Payment Receipt	Xerox copy (Duly signed by the scholar)
5.	DSC Formation Document **(FORM-3)**	Xerox copy (Duly signed by the-supervisor)
6.	Registration Certificate	Xerox copy (Duly signed by the-supervisor)
7.	List of Publications and Conference(s)	Xerox copy (Duly signed by the scholar and supervisor) of 1st page of each Publications
8.	Conference Presentation Certificates	Xerox copy (Duly signed by the scholar and supervisor)
DEADLINE OF SUBMISSION OF DOCUMENTS: Within 5 Working Days from the Date of Seminar		

4. LIST OF DOCUMENTS TO BE SUBMITTED DURING THESIS SUBMISSION FOR EVALUATION: (ALL DOCUMENTS TO BE SUBMITTED TOGETHER)

Sl. No.	List of the Documents	List of the Documents (to be Submitted to the Office of the Dean (AR)- in Printed Format)	List of the Documents (To be Sent to the Dean (AR) & Asso. Dean (AR) from the Chairperson, DSC through Mail in ZIP File)
1.	DSC Formation Document **(FORM-3)**	**FORM-3** (Duly signed by the supervisor(s))	Scan copy of **FORM-3** in Pdf format
2.	Thesis Submission Form **(FORM-8)**	**FORM-8** (In original)	Scan copy of **FORM-8** in Pdf format
3.	Plagiarism Report	Plagiarism Report in original & each page duly signed by the supervisor (s) and the scholar	Scan copy of original documents in Pdf format
4.	List of Examiners (summary) for Evaluation of PhD Thesis **(FORM-10)**	**FORM-10** in original	Scan copy of **FORM-10** in Pdf format Only Doc (Word) file without signature
5.	Lists of Indian & Foreign Examiners (in sealed envelope) **(FORM-11 and 12)**	In original	Scan Copy of **FORM-11 and 12** in Pdf format Doc (Word) file of FORM-11 and 12 without signature
6.	Thesis (Hard Bound)print in both sides within 200 pages)-One copy	Format of the thesis should be **as per the Latest PhD Regulations**	Pdf copy of the Thesis for evaluation **(Pdf file size should not be more than 10 MB)**
7.	Thesis submission fee Payment Receipt **(Rs. 6500/-) (Canara Bank, NIT Durgapur A/C No. 8569101000352, IFSC: CNRB0008569) ***Thesis submission Fee is 15,000/- for Scholars who got admitted in 2019 onwards**	In original (for bank payment in person) or **payment receipt verified by the Bank for online payment**	Pdf copy of the Synopsis (**Pdf file size should not be more than 1 MB**) Scan Copy of Original documents in Pdf format
FORM 8, 10,11,12 ARE TO BE SUBMITTED SEPARATELY IN A CONFIDENTIAL SEALED ENVELOPE THROUGH THE OFFICE OF RESPECTIVE DEPARTMENT/SECTION			

RK

5. LIST OF DOCUMENTS TO BE SUBMITTED TO CONDUCT PhD DEFENSE SEMINAR (ALL DOCUMENTS TO BE SUBMITTED TO THE DEAN (AR)

Sl. No.	List of the Documents	To be mailed all documents in Zip file to The Dean (AR)	List of the Documents (To be Submitted to the Office of The Dean (AR)- In Printed Format)	
1.	Intimation to Dean (AR) to conduct Defense Seminar	To be mailed to the Dean (AR)	**Not applicable**	**To be communicated for Official formalities at least 12-15 days before the date of Defense seminar**
2.	Formation of Committee for PhD Defense **(FORM-15)**	Doc (Word) file	Printed copies with signature of the supervisor (s)	
3.	Thesis Evaluation Reports (Duly signed by DSC Members) Indian and Foreign Examiner	PDf file	Printed copies with signature of the supervisor (s)	
4.	Compliance Reports (Duly signed by DSC Members) Indian and Foreign Examiner	PDf file	Printed copies with signature of the Scholar and supervisor (s)	
5.	PhD Thesis (**as per Latest PhD Regulations)**	PDf file	Not Applicable	

6. LIST OF DOCUMENTS TO BE SUBMITTED AFTER PhD DEFENSE SEMINAR (ALL DOCUMENTS TO BE SUBMITTED AT A TIME)

Sl. No.	List of the Documents	List of the Documents (to be Submitted to the Office of The Dean (AR))	
		In Printed Format	**Soft Copy in Pen Drive/ CD**
1.	Defense Seminar Notice	Original/ Xerox copy	Not Applicable
2.	Report on Viva-Voce & Defense **(FORM-14)**	In original	Not Applicable
3.	PhD Thesis (Hard Bound))	One copy (Format of the thesis should be **as per Latest PhD Regulations)**	Not Applicable
4.	Soft-copy of the thesis • Front matter with Abstract • Chapter Wise (Separately) • Full Thesis in one file	NA	✓ Pdf file
5.	Compliance Report	Printed copies Duly signed by the Scholar ,supervisor (s) and DSC Members	✓ Pdf file
6.	Thesis Evaluation Report (Indian & Foreign Examiner) **(FORM-13)**	Printed copies Duly signed by the Scholar ,supervisor (s)	✓ Pdf file
7.	No Dues from Hostel, Library & Department	In original	Not Applicable

RK

7. LIST OF DOCUMENTS TO BE SUBMITTED FOR INCLUSION OF CO-SUPERVISOR

Sl. No.	List of the Documents (to be Submitted to the Office of the Dean (AR)- in Printed Format)	REMARKS
1.	Application by the Scholar/candidate through Supervisors and the DSC	✓Duly signed by all the DSC Members & HoD/Chairperson (DSC), Stating "Recommended/Not Recommended" on the application ✓ Consent from the existing supervisor (s) on the application ✓Consent from the proposed supervisor (s) on the application
2.	Proposed Doctoral Scrutiny Committee (DSC) **(Form-3)**	In original
3.	Existing Doctoral Scrutiny Committee (DSC) **(Form-3)**	Xerox copy
4.	Curriculum Vitae of the External Faculty Member, Proposed as co-supervisor	In original
5.	Format of Willingness Certificate from the External Faculty Member who wishes to become Co-supervisor **(Form-16)**	In original
6.	Format of No Objection Certificate from the Employer of the External Faculty Member who wishes to become Co-supervisor **(Form-17)**	In original

8. LIST OF DOCUMENTS TO BE SUBMITTED FOR RE-SUBMISSION OF THESIS:

Sl. No.	List of the Documents (to be Submitted to the Office of the Dean (AR)- in Printed Format)	To be Submitted to the Office of The Dean (AR)- In Printed Format	To be Sent to the Dean (AR) & Asso. Dean (AR) from the Chairperson, DSC through Mail in ZIP File
1.	Ph.D. Thesis Re-Submission Form **(FORM-9)**	In original	Scan copy of original documents in Pdf format
2.	Thesis Resubmission Fee **(Rs. 1000/-)** payment receipt **(Canara Bank, NIT Durgapur A/c No. 8569101000352, IFSC: CNRB0008569)**	In original (for bank payment in person) or **payment receipt verified by the Bank for online payment**	Scan copy of original documents in Pdf format
3.	Revised PhD Thesis (Hard Bound)	One copy (Format of the thesis should be **as per Latest PhD Regulations)**	Pdf Copy
4.	Plagiarism Report (Revised Thesis)	Plagiarism Report in original & each page duly signed by the supervisor (s) and the scholars	Scan copy of original documents in Pdf format
5.	Compliance Report (Indian & Foreign Examiner)	Printed copies Duly signed by the Scholar, supervisor (s) and DSC Members	Pdf Copy
6.	Thesis Evaluation Report (Indian & Foreign Examiner) **(FORM-13)**	Printed copies Duly signed by the Scholar and supervisor (s)	Pdf Copy

Pk

राष्ट्रीय प्रौद्योगिकी संस्थान दुर्गापुर
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
MAHATMA GANDHI AVENUE, DURGAPUR-713209
West Bengal, INDIA, www.nitdgp.ac.in
(An Autonomous Institution of the Govt. of India under Ministry of Education
(Shiksha Mantralaya))

Ref. No. NITD/Estt./Acad/INFLIBNET/2022 Date:19/05/2022

OFFICE ORDER

As approved by the Competent Authority of the Institute, Dr. Jaydeep Howlader, Assistant Professor, Department of CSE & Professor In-Charge of Library is hereby nominated as **Coordinator** for the purpose of **INFLIBNET – Shodh Ganga** of the Institute for two years from the date of this issuance office order.

20/05/22

Registrar

Copy forwarded for information to:
1. Director
2. All Deans
3. All Head of the Departments
4. Dr. Jaydeep Howlader, Asst. Prof, CSE & Professor In-Charge, Library,
5. Director Secretariat & Registrar Secretariat,
6. File copy

19/5/2022

Joint Registrar (Establishment)

Chatterjee

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA

Ref: NITD/Inflibnet/

Date: 27.06.2022

<u>Guidelines for submitting the soft copy of the thesis for INFLIBNET Shodhganga – (after successful completion of PhD defense.)</u>

Sir/Madam,

The National Institute of Technology, Durgapur has signed a MoU with the INFLIBNET to participate in the Shodhganga platform which is maintained by University Grants Commission of India.

Shodhganga: A reservoir of Indian theses is a digital repository, submitted by Indian Universities.
To make the process effective, following standards may be maintained henceforth during submission of thesis from the respective Departments/Centers of the National Institute of Technology Durgapur.

1. An electronic copy of the thesis is to be submitted through designated Institute email account (meant for shodhganga purpose – to be intimated shortly) by the respective scholar through the Supervisor to the Coordinator INFLIBNET at the office of Dean – Academic Research of the National Institute of Technology, Durgapur for uploading to the Sodhganga Repository.

2. The files submitted electronically should not be password protected as the same needs to be processed before uploading to the Shodhganga Repository.

Please ensure to send the following information in the format below, while sending a submitted thesis and its electronic copy to the National Institute of Technology, Durgapur for archiving.

....

INFORMATION FOR SUBMISSION OF PhD THESIS SOFT COPY FOR INFLIBNET – Shodhganga.

Name of the Scholar :

Name of the Department / Centre :

Title of the Thesis :

Name of the Supervisor(s) :

Registration no. / Date of Registration :

Date of PhD Thesis defense :

Senate resolution no with date
(to be filled by the office of the Dean – AR). :

Keywords :

....
(Full signature of the Supervisor)
Date of submission:

....
(Full signature of the Scholar)

....

Thanking You.

J. HOWLADER 05/07/2022

Dean (Academic Research)
NIT DURGAPUR

Coordinator (INFLIBNET-Shodhganga)
NIT DURGAPUR

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA

Guidelines for Submission of e-Thesis for Shodhganga: INFLIBNET A Reservoir of Indian theses and Digital Archiving at Central Library of the National Institute of Technology Durgapur.

1. The Research Scholar needs to submit the thesis, along with the following documents in 02 (two) folders:

   - Folder-1 contains :

     a) The complete thesis after the defense (exactly same as the print version), as a single PDF file.
     b) The complete thesis split into multiple PDF files of different thesis sections and chapters. (Please see and follow Annexure III for splitting the thesis.)

   - Folder-2 contains :

     - An abstract (not exceeding 2500 characters) and thesis metadata in PDF format (Please see Annexure I and II).
     - Scanned copy of 'Consent Form for Digital Archiving'(Annexure – II) duly signed by the research scholar is also to be submitted.

2. In addition to the PDF document, scholars are also advised to submit supporting materials such as Audio files, Video files, Statistical results etc.(if any).

3. However, while submitting such contents it is advised to use proper open format. (For e.g. MP3 for audio files and MPEG4 for Video files etc).

4. The 'Thesis Metadata Form' (Annexure – I) to be duly filled and submitted by the research scholar in a PDF file (In Folder-2).

5. The files submitted electronically as mentioned above should not be password protected as the same needs to be processed before uploading to the Shodhganga Repository.

05/07/2022

Dean (Academic Research)
NIT DURGAPUR

Coordinator (INFLIBNET)
NIT DURGAPUR

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA

Annexure – I

E - Thesis Metadata Form

1.	Title(in Full) (Bold and CAPITAL)	
2.	Name of Research Scholar Personal email address Mobile phone no. Residential address in full	
3.	Date of Registration	
4.	Name of the Supervisor(s)	1. 2. 3 .
5.	Department/ Centre	
6.	Date of Submission after PhD defense	
7.	Subject Keywords	1. 2. 3. 4. 5 .
8.	File Format of thesis and accompanying material, if any (PDF, MPEG, etc.)	
9.	Any other relevant information	

Full Signature of the Research Scholar:________________________________

Date :________________________________

Rk

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INDIA

Annexure – II

<u>Consent Form for Digital Archiving</u>

Name of the Research Scholar	
Registration Number	
Department/ Centre	
Supervisor (s)	
Thesis Title	
Date of final Submission of PhD thesis	

- I am the sole owner of copyright on this thesis. The National Institute of Technology, Durgapur is hereby granted, non - exclusive, royalty- free and non - transferable rights to make available, in full or in part without any modifications, this thesis in electronic/ printed form for public use at no charge. Any use of material from this thesis/ dissertation must be accompanied with appropriate citation.

- I wish to allow open access to my thesis.

Signature of the Scholar in full
Place :
Date :

(1) Signature of the Supervisor.
Place:
Date:

(2)Signature of the Supervisor.
Place:
Date:

(3)Signature of the Supervisor.
Place:
Date:

RK

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INDIA

Annexure – III

Submission report on splitting of the files in chapters to upload on "Shodhganga" in PDF format.

Sl. No.	Description	Submitted (Yes / No)	Remarks (if any)
1	Title	Yes / No	
2	Certificates	Yes / No	
3	Acknowledgement	Yes / No	
4	Contents	Yes / No	
5	Preface/abstract	Yes / No	
6	List of tables figures (including figures, algorithm, list of abbreviation and any such items)	Yes / No	
7	Chapter 1	Yes / No	
8	Chapter 2	Yes / No	
9	Chapter 3	Yes / No	
10	Chapter 4	Yes / No	
11	Chapter 5	Yes / No	
12	Chapter 6	Yes / No	
13	Chapter 7	Yes / No	
14	Reference	Yes / No	
15	Appendix	Yes / No	
16	Any other additional file	Yes / No	

Signature of the Scholar in full
Place :
Date :

(1) Signature of the Supervisor.
Place:
Date:

RK

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA.
Website: www.nitdgp.ac.in

Advt. No.: NITD/AR/PhD/2022-23/Odd Sem. **Date: 23.06.2022**

Admission to Various Regular and Professional Ph.D Programs (Odd Semester/2022-23)
(As per the Ph.D Regulations of NIT Durgapur)

Applications are invited from eligible candidates for Admission to PhD programs, Odd Semester, 2022-23 under the following categories:

CATEGORY-A. Regular Research Scholar with Institute Fellowship:
Vacancies of Different Departments:

		Vacancy of Regular Research Scholar with Institute Fellowship (Category-wise)										
Sl. No.	**Department**	**OP**	**OP-PWD**	**EWS**	**EWS-PWD**	**OBC - NCL**	**OBC-NCL-PWD**	**SC**	**SC-PWD**	**ST**	**ST-PWD**	**Total**
1	Biotechnology (BT)	3	0	1	0	2	0	1	0	1	0	8
2	Civil Engineering (CE)	2	0	1	0	1	1	1	0	1	0	7
3	Chemical Engineering (CH)	2	0	1	0	2	0	1	0	0	1	7
4	Computer Science & Engineering (CS)	6	1	1	0	4	0	2	0	1	0	15
5	Chemistry (CY)	3	0	1	0	1	0	1	0	0	0	6
6	Electronics & Communication Engineering (EC)	2	0	1	0	2	0	1	0	1	0	7
7	Electrical Engineering (EE)	4	0	1	0	2	0	1	0	1	0	9
8	Earth and Environmental Studies (ES)	1	0	0	0	0	0	0	0	1	0	2
9	Humanities & Social Sciences (HS)	1	0	0	0	1	0	0	1	0	0	3
10	Mathematics (MA)	2	0	1	0	2	0	1	0	0	0	6
11	Mechanical Engineering (ME)	5	0	1	0	3	0	2	0	1	0	12
12	Metallurgical & Materials Engineering (MM)	3	0	1	0	1	1	1	0	0	0	7
13	Management Studies (MS)	2	0	0	0	2	0	1	0	0	0	5
14	Physics (PH)	3	0	0	0	2	0	1	0	0	0	6

CATEGORY-B : Regular Research Scholar with Financial Support from the Government Programs (sponsored by DST, CSIR, UGC etc.)
Candidates seeking admission to PhD program having their fellowship from various government organisations such as CSIR, UGC, DBT, DST-INSPIRE, etc. (No Objection Certificate from the proposed Supervisor in the given format is to be submitted mandatorily during the application and admission process)**.**

CATEGORY-C : Regular Research Scholar Selected in Externally Funded Sponsored Projects in the Institute (No Objection Certificate from the Principal Investigator/Proposed Supervisor, indicating the duration for which the fellowship is available in the given format is to be submitted mandatorily during the application and admission process).

CATEGORY-D : Regular Research Scholar under QIP/EFIP Scheme (Not Applicable).
CATEGORY-E. Regular Foreign Research Scholar Admitted through Government of India (Not Applicable).

CATEGORY-F : Professional Research Scholar from the Institute (NIT Durgapur Faculty / Staff): (No Objection Certificate must be submitted from the Head of the Institute during the application and admission process).

CATEGORY-G : Regular Sponsored Research Scholar from Government/ Semi-Government/ other Highly Reputed Organizations/Academic or Research Institutions (No Objection Certificate /Sponsorship Certificate in the given format is to be submitted mandatorily during the application and admission process).

CATEGORY-H: Professional Sponsored Research Scholar from Reputed Industries (Industry Research Program): (No-objection certificate or Sponsorship certificate from the employer in the given format is to be submitted mandatorily during the application and admission process).

CATEGORY-I : Professional Research Scholar from Academic/ Research Institutions (No Objection Certificate from the Head of the Institute in the given format is to be submitted mandatorily during the application and admission process).

CATEGORY-J : Professional Sponsored Research Scholar under Government of India Schemes like TEQIP etc. (Will be guided by TEQIP norms).
NOT APPLICABLE

Category-K. : Regular Research Scholar without Institute Fellowship (Self-sponsored)
(Research Scholars under category K will pursue PhD programme at the Institute on full time basis without getting financial assistance from NIT Durgapur or any other funding agency.)

Availability of Seats under Various Categories of Regular and Professional Research Scholars (Category- B, C, F, G, H, I, J, and K) other than 'A' in Different Departments & Centres are given below:

Departments	B	C	F	G	H	I	J	K
Biotechnology (BT)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Civil Engineering (CE)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Chemical Engineering (CH)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Computer Science& Engineering (CS)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Chemistry (CY)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Electronics & Communication Engineering (EC)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Electrical Engineering (EE)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Earth and Environmental Studies (ES)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Humanities & Social Sciences (HS)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Mathematics (MA)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Mechanical Engineering (ME)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Metallurgical & Materials Engineering (MM)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Management Studies (MS)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Physics (PH)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Centres								
Centre for Research on Environment and Water (CREW)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Centre for Biomedical Engineering & Assistive Technology (BEAT)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Centre for Advanced Research on Energy (CARE)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Centre of Excellence on IoT and Intelligent Systems (IoTIS)	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes

NA: Not applicable

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA.
Website: www.nitdgp.ac.in

Minimum Eligibility Criteria for Admission to PhD Program (Odd Sem./ 2022-23)

<table>
<tr><th>Qualifying Degree*
(for relevant discipline)</th><th>General/ OBC</th><th>SC / ST</th><th>Academic and other Qualifications</th></tr>
<tr><td>M. Tech./ M.E./ M. Arch/ M. Pharm / M. S. / MBA/ PGDBM/ PGDM</td><td>6.5 CGPA or 60% marks</td><td>6.0 CGPA or 55% marks</td><td rowspan="6"><u>Category A:</u>
B. Tech/ B.E./ B. Arch/ B. Pharm / Equivalent with valid GATE.
M. Tech./ M.E./ M. Arch/ M. Pharm degrees with or without GATE qualification.
Other Post Graduate or Graduate degrees (as listed) with any relevant NET qualification.
List of NETs:
CSIR, UGC, GATE, GPAT, DBT-JRF, JEST, ICMR, ICAR, NBHM, Bioinformatics National Certification Examination etc.
However, these NET qualifications will have to be relevant to the qualifying degree of the candidate concerned.
(OM No. SB/S9/2-01/2015 dated 07.01.2015)

<u>Categories B, C, D and E:</u>
As per the terms and conditions of the funding or sponsoring agency.

<u>Categories F, G, H, I, J, and K</u>:
Same as category A, but GATE/NET qualification is not mandatory.</td></tr>
<tr><td>M. Sc./ M. Com./ MBBS/ BDS</td><td>6.5 CGPA or 60% marks</td><td>6.0 CGPA or 55% marks</td></tr>
<tr><td>MA</td><td>6.0 CGPA or 55% marks</td><td>5.5 CGPA or 50% marks</td></tr>
<tr><td>MCA</td><td>7.5 CGPA or 70% marks</td><td>7.0 CGPA or 65% marks</td></tr>
<tr><td>B. Tech/ B.E./ B. Arch/ B. Pharm / Equivalent</td><td>7.5 CGPA or 70% marks</td><td>7.0 CGPA or 65% marks</td></tr>
<tr><td>CA/ ICWAI/ CS with a graduation degree</td><td>6.0 CGPA or 55% marks</td><td>5.5 CGPA or 50% marks</td></tr>
</table>

*All the degrees must be from an Institute/University recognized by UGC/AICTE/MoE, Govt. of India.
The eligibility criteria as given above is the minimum requirement only. Good academic career and higher qualification will be preferred. However, satisfying the mere eligibility shall not ensure a call for admission test and/or viva voce.

Candidates need to mention CGPA alongwith the Percentage of marks as awarded by their University/Institute only. In case of unavailability of Percentage of marks, NIT Durgapur norms for conversion of CGPA to the Percentage of marks will be applicable.

Relevant Academic Qualification Details of Various Departments are Listed Below:

Department	Details of Relevant Disciplines (ODD SEM / 2022-23)
Biotechnology (BT)	B. Tech. /M. Tech/ MS/ M. Sc/B. Pharm./ M. Pharm./MBBS/BDS or equivalent degree in relevant discipline.
Civil Engineering (CE)	(i) B. Tech./B.E. or equivalent in Civil Engineering /Construction Engineering /Earthquake Engineering /Structural Engineering /Aerospace Engineering OR in any branch of Engineering that may be considered for research areas consistent with Civil /allied Engineering, WITH OR WITHOUT M.E./M. Tech./ M.S. in the relevant discipline. (ii) 5 year Integrated/ dual degree M. Tech. in Civil Engineering /Construction Engineering /Earthquake Engineering / Structural Engineering /Aerospace Engineering.

Chemical Engineering (CH)	**Category A** (i) B. E. /B. Tech. in Chemical Engineering/ Chemical Technology/ Mechanical Engineering/ Metallurgical/ Metallurgical and Materials Engineering/ Civil Engineering/ Bio technology/Polymer Technology (ii) B.E. / B. Tech. in Chemical Engineering/ Chemical Technology/ Mechanical Engineering/ Metallurgical/ Metallurgical and Materials Engineering/ Civil Engineering/ Bio technology/Polymer Technology with M.E./M. Tech./M.S. in any relevant discipline. (iii) 5 year Integrated/ dual degree M. Tech. in Chemical Engineering. (iv) M. Sc. in Chemistry/Physics/Mathematics /Environmental Sc. or Engg. (with Maths in HS or 10+2 level) The candidate must have completed the academic program(s) in normal duration with no repeat of years. **Categories B to J: (Any of the following)** (i) B. E./ B. Tech. or equivalent in Chemical Engineering or in any relevant discipline. (ii) M.E./ M. Tech. or equivalent in Chemical Engineering or in any relevant discipline. (iii) 5 year Integrated /dual degree M. Tech. in Chemical Engineering or any relevant discipline. (iv) M. Sc. in any relevant discipline.
Computer Science & Engineering (CS)	(i) UG Programme in Engg. /Tech. in CSE/IT/ECE/EE GATE (Qualified/valid Score) in CS only **Or** (ii) Two Year PG programme in Engg. /Tech in CSE/IT/ECE/EE, **Or** MCA/MSc.(Comp.Sc.) with relevant NET qualification (in JRF) /GATE (Qualified/valid Score) in CS only.
Chemistry (CY)	M.Sc. or M. Tech. in Chemistry/Applied Chemistry/ Engineering Chemistry/Chemical Science or Technology / Engineering/ Biochemistry/ Biological science/ Environmental Science or Technology / Engineering/ Material Science or Technology / Engineering (plastics, polymer, corrosion, nanotechnology, Biotechnology and related areas). In addition, chemistry should be one of the subjects at UG levels.
Electronics & Communication Engineering (EC)	Four year undergraduate programme in Engg. or Tech. in ECE/ EE/ CSE/ IT/ EI or an allied area **Or** M. Sc. (Physics) with specialization in Electronics/ Radio Physics and Electronics/ Material Science. **Or** M. Sc. (Electronics Science)/ M.Sc. (Electronics) **Or** Two year post graduate programme in Engineering/ Technology in ECE/ EE/ CSE/I T/ EI or an allied area. **Or** Integrated post graduate programme in Engg. or Technology in ECE/ EE / CSE /IT/EI.
Electrical Engineering (EE)	(i). B.E. / B. Tech. or Equivalent Degree in- (a) Electrical Engineering (EE), (b) Electrical & Electronics Engineering (EEE), (c) Electronics Engineering, /Electronics and Communication/Telecommunication Engineering (ECE), (d) Computer Science Engineering (CSE),(e) Electrical, Electronics & Computer Science Engineering (EECS), (f) Applied Electronics and Instrumentation Engineering (AEIE/EIE), (g) Instrumentation Engineering (IE), (h) Instrumentation and Control Engineering (ICE). **And** (ii). M. E. / M. Tech./ M. S. or any equivalent post graduate degree in the relevant disciplines with indicative broad area of research available: (a) Power System, (b)Electrical Machines, (c) Power Electronics, (d) Power Electronics & Machine Drives, (e) High Voltage Engg., (f) Control System, (g) Instrumentation/ Measurement, (h) Instrumentation & Control, (i) Bio-Medical Instrumentation, (j) Energy Systems/ Renewal Energy Systems, (k) Power Plant Engineering, (i) Internet of Things (IoT),(m) Embedded System, (n)Artificial Intelligence (AI), (o) Machine Learning (ML), (p) Image Processing, (q) Mechatronics,(r) Microwave Engineering, RF Microwave Engineering, (s) Computer networks, (t)

	Micro Electronics and VLSI, (u) Communication Engineering. **Or** B.E. / B. Tech. or equivalent with valid GATE score in EE.
Earth and Environmental Studies (ES)	M.Sc. /M.S. /M. Sc.(Tech.) in Geology/ Earth Science/Applied Geology and Geo informatics/ Applied Geology/ Geochemistry / Hydrogeology (or Ground water)/Agriculture. B. Tech./B.E. in Environmental Engineering/ Civil Engineering / Water Resources Engineering or Management; M. Tech./M.E. in Environmental Engineering/ Environmental Science and Technology/Water Resource Engineering/ Agricultural Engineering.
Humanities & Social Sciences (HS)	Economics: M.A. or M.Sc. in Economics/ Statistics/ Commerce. Interested candidates from other disciplines with PG degree may also apply, subject to the assessment of suitability by the department. English: M.A. in English/ Linguistics/ Cultural Studies. Interested candidates from other disciplines with PG degree may also apply, subject to the assessment of suitability by the department.
Mathematics (MA)	P.G. degree in Mathematics/ Statistics/ Computer Science/ Physics, **Or** MCA **Or** M. Tech. with the following specilizations: Operations Research, Operations Management, Optimization
Mechanical Engineering (ME)	Eligible degrees (i) B.E./ B. Tech. in Mechanical Engg./Production Engg. Or (ii) M. E./M. Tech. with the following specializations (a) Thermal Engg./Heat Power Engg, (b) Production Engg / Manufacturing Engg., (c) Machine Design, (d) Fluid Mechanics/Hydraulic Machines, (e) Power Engg., (f) Automobile Engg., (g) Applied Mechanics, (h) Mechatronics, (i) Robotics.
Metallurgical & Materials Engineering (MM)	B.Tech in Metallurgical and Materials Engineering/Mechanical Engg. /Production Engg./Ceramic Engg./Manufacture Engg./ Materials Science/Aeronautical Engg./Aerospace Engg./Nanoscience and Nanotechnology. **Or** M. Tech. in Metallurgical and Materials Engineering/Mechanical Engg./ Production Engg./Ceramic Engg./Manufacture Engg/Materials Science/Aeronautical Engg/Aerospace Engg./ Nanoscience and Nanotechnology. **Or** M. Sc. in Physics or Chemistry.
Management Studies (MS)	MBA with Specialization in Marketing or Finance or HR or HR & OB or Systems & Operations, OR Post Graduate Degree either in Economics or Statistics or Commerce or Psychology or Applied Psychology. **Or** B.Tech./M.Tech. with interest in doing research in Management and related disciplines. However, suitability of related disciplines will be judged by the Department.
Physics (PH)	M.Sc. in Physics/Applied Physics/Materials Science/Nanotechnology/Biophysics/ Electronics Science. **Or** M. Tech. in (Materials Science/Nanotechnology or equivalent).
Centres	
Centre for Research on Environment and Water (CREW)	B.Tech. /B. E. in Environmental Engineering/ Civil Engineering / Chemical Engineering / Water Resources Engineering or Management /Biotechnology/Metallurgy & Materials Sc./Computer Sc. **Or** M. Tech. /M. E./ M. Tech . Dual Degreein Environmental Engineering/ Environmental Science and Technology/ Agricultural Engineering / Nano Science and Technology/Civil Engineering / Chemical Engineering / Water Resources Engineering or Management /Biotechnology/Metallurgy & Materials Sc./ Computer Sc. **Or** M. Sc./MS/M.Sc. (Tech) in Geology/ Earth Science/ Applied Geology/ Geochemistry /

	Hydrogeology (or Groundwater) /Agriculture/Chemistry/Applied Chemistry/Physics/Mathematics/Biotechnology/M. Sc or M. Sc. (Tech) in Applied Physics, Geophysics, Biophysics, Engineering Physics, Environmental Science, Microbiology, Zoology, Botany, Applied Chemistry, Radiochemistry, Radiophysics, Geochemistry, Engineering Chemistry, Atmospheric Science, Ocenography, Computation Bioscience, Computational Geoscience, Seismology.
Centre for Biomedical Engineering & Assistive Technology (BEAT)	i) M. Tech./M.E. or equiv. in Biomedical Engineering, Chemical Engineering, Computer Science & Engineering, Electrical Engineering, Electrical & Electronics Engg., Electronics & Telecommunications Engineering, Instrumentation Engineering, Mechanical Engineering, Metallurgical and or Material Science Engineering. **Or** ii) M. Pharm. OR MBBS with or without MD/MS. **Or** iii) B. Tech./B.E. or equivalent degree in Biomedical Engineering, Chemical Engineering, Computer Science & Engineering, Electrical Engineering, Electrical & Electronics Engg., Electronics & Telecommunications Engineering, Instrumentation Engineering, Mechanical Engineering, Metallurgical and or Material Science Engineering with a GATE qualified score or a CSIR/UGC/DBT/ICMRJRF (qualified score). **Or** iv) M.Sc. or equiv. in Biochemistry, Biophysics, Biotechnology, Ceramics, Chemistry, Electronics, Ergonomics, Material Science, Mathematics, Molecular Biology, Physics and Physiology with a GATE qualified score or a CSIR/UGC/DBT/ICMRJRF (qualified score). **Or** v) Health Sciences such as MBBS / BDS. Must qualify All India level post graduate entrance examination for relevant disciples. **Or** vi) B. Pharm. (with GPAT entrance examination) **Broad Research Area available:** (i) Biomaterials & Biofabrication, (ii)Biomechanics & Biomechanical Engineering, (iii) Biomedical Devices, Bio-Instrumentation & Bio-sensors, (iv) Assistive Technology & Rehabilitation Engineering.
Centre for Advanced Research on Energy (CARE)	M. E. / M. Tech./ M. Pharm. /M. Sc / M. S. or any Equivalent Post Graduate Degree in the Relevant Disciplines. **Or** B.E./B. Tech. or equivalent with GATE.
Centre of Excellence on IoT and Intelligent Systems (IoTIS)	i). B.E. / B. Tech. in Branch of Engineering /Technology **Or** ii). M.E. / M. Tech./MCA or equivalent **Or** iii). M. Sc. with requisite CGPA/percentage and NET qualification. Note: Proficiency in programming and mathematics/statistics is highly desirable and such skills will be tested during admission process.

SCHOLARSHIP/FELLOWHIP/FINANCIAL SUPPORT

Scholarship/Fellowhip/Financial Support as per the norms of Ministry of Education (MoE), Government of India shall be available to all selected **Regular Research Scholars (Category- A). The matter of** Scholarship/Fellowhip/Financial Support **will be looked after by the office of Dean (SW).**

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA.
Website: www.nitdgp.ac.in

APPLICATION PROCEDURE:

Mode of Application: Online (visit the Institute website www.nitdgp.ac.in).

Application Fee: The application fee of Rs 2,000/- (Rs 1,500/- for SC/ST/PwD and Women candidates), which is **non-refundable**, has to be paid to the following account through NEFT or IMPS only.
However, a valid document as proof of payment of successful transaction has to be produced by the candidate.

Account Details for Payment of Application Fee:

- Name of the Account: National Institute of Technology Durgapur
- Account Number: 8569101000352
- Name of the Bank: Canara Bank
- Name of the Branch: NIT Durgapur
- IFSC Code:CNRB0008569

Events	Dates
Opening Date for submission of Online Application	24/06/2022 (5:00 PM)
Closing Date for submission of Online Application	12/07/2022 (5:00PM)
Publication of Applicant's List	18/07/2022
Verification of Submitted documents by the Respective Departments / Centres	18/07/2022-21/07/2022 (3:00PM)
Publication of Shortlisted Candidates on the Institute website as prepared by the respective Departments / Centres	26/07/2022
Admission test and Viva-voce by the Respective Departments / Centres	01/08/2022-05/08/2022
Publication of Results on the Institute website	10/08/2022
Admission and Enrollment of Selected candidates/ Physical Reporting to the Institute	16/08/2022-22/08/2022 (on working days only)
Publication of WAITLIST Candidates if any	26/08/2022
Admission of Candidates from Waitlist, if required	29/08/2022-31/08/2022

****The above dates may be changed depending on the condition of the pandemic situation. The applicants are advised to follow the institute website time to time for the updates, if any.***

SELECTION PROCEDURE FOR PhD PROGRAMMES

(i) Selection of PhD candidates under categories A, B, C, G, I & K:

The shortlisting of applications will be made by the respective departments based on the documents submitted (online) and only the shortlisted candidates will be intimated for online admission test and viva voce (online) on the notified date. ***All shortlisted candidates shall appear for the admission test offline/online***. There may be a further screening after the conduction of the admission test and before viva-voce, depending upon the number of candidates.

(ii) Selection of PhD candidates under categories F, H, & J:

Selection under these categories will be made directly subject to fulfillment of eligibility criteria fixed by the respective departments. **A shortlisting of applications will be made and the shortlisted candidates only will be called for viva-voce offline/online.**

(iii) The outline of the syllabus of the admission test: Candidates are referred to check the webpage of the respective Departments/Centres in the Institute website.

The admission committees of the respective departments are fully empowered and responsible for selection and their decision is final in the admission process.

The List of Selected Candidates will be published on the Institute website(www.nitdgp.ac.in).

HOSTEL ACCOMMODATION:

NIT Durgapur is a residential institute. Each and every regular scholar will be required to reside in hostels as per Institute rules, subject to the availability of vacant seats and regarding the matter of accommodation the office of Dean (SW) may be contacted.

FEES STRUCTURE OF PhD PROGRAMS OF ALL CATEGORIES:

The Fee structure for the Academic Session 2022-23 will be available in the Institute website(www.nitdgp.ac.in).

PhD REGULATIONS:

The admitted scholars will be subjected to PhD Regulations, 2022 (Amended) and further Amendments on Ph.D Regulations, 2022, if any, will be published in the Institute website. Applicants are advised to go through the details of rules & regulations available on the institute website (www.nitdgp.ac.in).

APPLICATION CHECKLIST FOR VARIOUS CATEGORIES *(DOCUMENTS TO BE UPLOADED ONLINE)*:

A. Regular Research Scholar with Institute Scholarship:

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of document as proof of payment of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. Self-attested copy of valid certificate (SC/ST) from a competent authority as per the format given in the website, if applicable.
15. Self-attested copy of valid certificate in case of OBC candidates from a competent authority as per the format given in the website indicating the status regarding creamy layer, issued on or after 01/04/2022, if applicable.
16. Self-attested of valid certificate in case of EWS candidates from a competent authority as per the format given in the website indicating the status regarding creamy layer, issued on or after 01/04/2022, if applicable.
17. Self-attested copy of valid Person with Disability (PwD) certificate from a competent authority as per the format given in the website, if applicable.

&

18. **Self-attested copy of NET / GATE qualification certificate (as described in the eligibility criteria), as applicable.**
19. **Self-attested copy of course completion certificate / Transcript for Result Awaited candidates.**
20. Self-attested copy of any other relevant documents.

B. Regular Research Scholar with Financial Support from Government Programs (sponsored by DST, CSIR, UGC etc.)

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).

4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of document as proof of payment of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. **Self-attested copy of a NET/ GATE qualification certificate, as per the requirement of the corresponding funding agency (in case of non-requirement, a valid supporting document for non-requirement of NET/GATE qualification has to be produced), as applicable.**
15. **Self-attested copy of No Objection Certificate from the Project Supervisor as per the format given in the website.**
16. Self-attested copy of any other relevant documents.

C. Regular Research Scholar Selected in Externally Funded Sponsored Projects in the Institute

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. **Self-attested copy of a NET/ GATE qualification certificate, as per the requirement of the corresponding funding agency (in case of non-requirement, a valid supporting document for non-requirement of NET/GATE qualification has to be produced), as applicable.**
15. **Self-attested copy of No Objection Certificate from the Principal Investigator as per the format given in the website, indicating the duration for which the fellowship is available.**
16. Self-attested copy of any other relevant documents.

F. Professional Research Scholar from the Institute (NIT Durgapur Faculty / Staff)

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).

5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. **Self-attested copy of No Objection Certificate from the employer as per the format given in the website.**
15. Self-attested copy of any other relevant documents.

G. Regular Sponsored Research Scholar from Government/ Semi-Government/ other Highly Reputed Organizations/Academic or Research Institutions

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. **Self-attested copy of No Objection Certificate from the present employer as per the format given in the website.**
15. **Self-attested copy of Sponsorship Certificate from the present employer as per the format given in the website.**
16. Self-attested copy of any other relevant documents.

H. Professional Sponsored Research Scholar from Reputed Industries (Industry Research Program)

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.

12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. Self-attested copy of No Objection Certificate from the present employer as per the format given in the website.
15. Self-attested copy of Sponsorship Certificate from the present employer as per the format given (for sponsored candidates).
16. Self-attested copy of any other relevant documents.

I. Professional Research Scholar from Academic/ Research Institutions

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. Self-attested Pdf copy of No Objection Certificate from the present employer as per the format given in the website.
15. Self-attested copy of any other relevant documents.

J. Professional Sponsored Research Scholar under Government of India Schemes like TEQIP etc. (will be guided by TEQIP norms). **NOT APPLICABLE**

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. Self-attested copy of No Objection Certificate from the present employer as per the format given in the website.
15. Self-attested copy of Sponsorship Certificate from the sponsorer as per the format given in the website.
16. Self-attested copy of any other relevant documents.

Category-K. Regular Research Scholar without Institute Fellowship (Self-sponsored)

1. Self-attested copy of marks sheet / Grade card of 10th Standard Examination.
2. Self-attested copy of marks sheet / Grade card of 12th Standard Examination.
3. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Bachelor/UG program).
4. Self-attested copy of marks sheet / Grade card of the University/Institute Examinations (Masters/PG program).
5. Self-attested copy of Certificate of 10th Standard Examination.
6. Self-attested copy of Certificate of 12th Standard Examination.
7. Self-attested copy of Certificate of the University/Institute Examinations (Bachelor/UG program).
8. Self-attested copy of Certificate of the University/Institute Examinations (Masters/PG program).
9. Self-attested copy of relevant document showing CGPA-Percentage of marks conversion as followed in the qualifying degree awarding University / Institute.
10. Self-attested copy of proof of date of birth (Valid Birth certificate/ Admit card (10th Standard Examination).
11. Self-attested copy of payment for proof of application fees.
12. Self-attested copy of valid photo identity proof (Passport /Aaddhar card / Voter ID card).
13. Recent colour Photograph of Size: 3.5 cm x 3.5 cm in JPEG Format Only.

&

14. **(a) For employed candidate**:-Self-attested copy of No Objection Certificate from the present employer as per the format given in the website.
    (b) For unemployed/self-employed candidate:- Self-declaration as per the format given in the website.
15. Self-attested copy of any other relevant documents.

NOTE: In addition to the above documents, all aspiring candidates are required to upload/submit her/his full Signature (Size: 200px X 80px in JPEG/ JPG/ PNG Format Only) during the submission of online application form.

All announcements related to PhD admission will be made through the Institute website (www.nitdgp.ac.in). No communication will be made to any individual separately. Candidates are requested to visit the Institute website from time to time as required. The Institute will not be responsible in any manner if a candidate fails to visit /access the website in time.

The selected candidates will be required to produce all the original documents (as mentioned above for different categories, as applicable) for verification during their Admission Test/Physical Reporting/Admission (dates to be announced later) to the institute. Selected candidates are also advised to bring the printed application form, three copies of colour passport size photograph and a set of self-attested photocopies of all the required documents during Admission/Physical Reporting.

Additionally, all the selected candidates who will eventually turn out to be suitable for admission, will be required to submit **the migration certificate (in orginal)** at the time of physical reporting to the institute during the admission.

Misinformation/wrong information, submission of incomplete application, partly submitted application and submission of incorrect or false documents (during the process of application/admission) will lead to rejection of the application/ candidature at any time and the submitted fees, if any, will not be refunded.

Respective Department / Centre reserves the right to cancel incomplete applications (including applications submitted without relevant documents), if any. No correspondence/interim inquiries will be entertained from the candidates in connection with the process of selection including reasons for not being called for admission test / viva voce. Canvassing in any manner would also entail disqualification of the candidature.

Dean (Academic Research)
NIT Durgapur

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
Office of Dean (Academic Research)
Mahatma Gandhi Avenue, Durgapur-713209, West Bengal, INDIA

FORMATS OF CERTIFICATES/DECLARATIONS & UNDERTAKINGS FOR PhD ADMISSION 2022-2023

1. Format for OBC- NCL Certificate
2. Format for EWS Certificate
3. Format for SC/ST Certificate
4. Disability Certificate Formats
5. Format for Dyslexia Certificates
6. Format of Course Completion Certificate
7. Format of Self Declaration about Course Completion
8. Format of Self Declaration about Non Availability of Prefinal Year / Semester Marksheet
9. Format of Self Declaration about Non Availability of Provisional / Degree Certificate
10. Undertaking for Caste Validity Certificate for Maharashtra State Candidates
11. Undertaking to be submitted by GEN-EWS Candidates, not having the GEN-EWS Certificate Issued on or after 1st April 2022
12. Undertaking to be submitted by OBC-NCL Candidates, not having the OBC-NCL Certificate issued on or after 1st April, 2022
13. No Objection Certificate for Professional Ph.D
14. No Objection Certificate from NIT Durgapur
15. No Objection Certificate from Principal Investigator for Projects
16. No Objection Certificate from Supervisors for DST-Inspire, CSIR, UGC fellowship
17. Sponsorship Certificate for Ph.D. Programme
18. Declaration for Category K (Regular Research Scholar Without Institute Fellowship (Self-Sponsored)) for Unemployed/Self-Employed Candidates
19. No Objection Certificate for Category K (Regular Research Scholar Without Institute Fellowship (Self-Sponsored)) for Employed Candidates

FORMAT FOR OBC [NCL] CERTIFICATE

TO BE PRODUCED BY OTHER BACKWARD CLASSES APPLYING FOR ADMISSION

[This certificate must be issued on or after 1st April, 2022]

This is to certify that Shri/Smt./Kum.______________________________Son/Daughter of Shri/Smt.

___________________________________ of Village/Town __________________________________

District/Division___________________________in the_________________________State/UT

belongs to the__________________Community which is recognized as a backward class under:

(i) Resolution No. 12011/68/93-BCC(C), dated 10/09/93 published in the Gazette of India Extraordinary Part I Section I No. 186, dated 13/09/93.

(ii) Resolution No. 12011/9/94-BCC, dated 19/10/94 published in the Gazette of India Extraordinary Part I Section I No. 163, dated 20/10/94.

(iii) Resolution No. 12011/7/95-BCC, dated 24/05/95 published in the Gazette of India Extraordinary Part I Section I No. 88, dated 25/05/95.

(iv) Resolution No. 12011/96/94-BCC, dated 9/03/96.

(v) Resolution No. 12011/44/96-BCC, dated 6/12/96 published in the Gazette of India Extraordinary Part I Section I No. 210, dated 11/12/96.

(vi) Resolution No. 12011/13/97-BCC, dated 03/12/97.

(vii) Resolution No. 12011/99/94-BCC, dated 11/12/97.

(viii) Resolution No. 12011/68/98-BCC, dated 27/10/99.

(ix) Resolution No. 12011/88/98-BCC, dated 6/12/99 published in the Gazette of India Extraordinary Part I Section I No. 270, dated 06/12/99.

(x) Resolution No. 12011/36/99-BCC, dated 04/04/2000 published in the Gazette of India Extraordinary Part I Section I No. 71, dated 04/04/2000.

(xi) Resolution No. 12011/44/99-BCC, dated 21/09/2000 published in the Gazette of India Extraordinary Part I Section I No. 210, dated 21/09/2000.

(xii) Resolution No. 12016/9/2000-BCC, dated 06/09/2001.

(xiii) Resolution No. 12011/1/2001-BCC, dated 19/06/2003.

(xiv) Resolution No. 12011/4/2002-BCC, dated 13/01/2004.

(xv) Resolution No. 12011/9/2004-BCC, dated 16/01/2006 published in the Gazette of India Extraordinary Part I Section I No. 210, dated 16/01/2006.

(xvi) Resolution No. 12015/2/2007-BCC, dated 18/08/2010.

(xvii) Resolution No. 12015/2/2007-BCC, dated 11/10/2010.

(xviii) Resolution No. 12015/13/2010-BC-II, dated 08/12/2011.

(xix) Resolution No. 12015/05/2011-BC-II, dated 17/02/2014.

(xx) Resolution No. 12011/6/2014-BC-II, dated 07/12/2016.

(xxi) Resolution No. 12011/13/2016-BC-II, dated 22/12/2016

(xxii) Resolution No. 20012/1/2017-BC-II, dated 19/01/2017

(xxiii) Resolution No. 12011/7/2017-BC-II, dated 31/07/2017

Shri/Smt./Kum.___________________________and/or his family ordinarily reside(s) in the ___________________________District/Division of_________________________State/UT. This is also to certify that he/she **does not belong to the persons/sections (Creamy Layer)** mentioned in Column 3 of the Schedule to the Government of India, Department of Personnel & Training O.M. No. 36 012/22/93-Estt.(SCT), dated 08/09/93 which is modified vide OM No. 36033/3/2004 Estt.(Res.), dated 09/03/2004, further modified vide OM No. 36033/3/2004-Estt. (Res) dated 14/10/2008, again further modified vide OM No. 36036/2/2013-Estt (Res) dated 30/05/2014.

Place_____________________ **Signature** ___________________________

Date_________________ **Designation** ___________________________

(with seal of office)

NOTE:

(a) The term 'Ordinarily' used here will have the same meaning as in Section 20 of the Representation of the People Act, 1950.

(b) ^The authorities competent to issue Caste Certificates are indicated below:

- (i) District Magistrate / Additional Magistrate / Collector / Deputy Commissioner / Additional Deputy Commissioner / Deputy Collector / First Class Stipendiary Magistrate / Sub-Divisional magistrate / Taluka Magistrate / Executive Magistrate / Extra Assistant Commissioner (not below the rank of 1^{ST} Class Stipendiary Magistrate).
- (ii) Chief Presidency Magistrate / Additional Chief Presidency Magistrate / Presidency Magistrate.
- (iii) Revenue Officer not below the rank of Tehsildar.
- (iv) Sub-Divisional Officer of the area where the candidate and / or his family resides.

FORMAT FOR EWS CERTIFICATE

INCOME & ASSEST CERTIFICATE TO BE PRODUCED BY ECONOMICALLY WEAKER SECTIONS

Government of ………………………………..

(Name & Address of the authority issuing the certificate)

[This certificate must be issued on or after 1st April 2022]

Certificate No .________________________ Date:_________________

VALID FOR THE YEAR_____________

1. **This is to certify that Shri /Smt. / Kumari_________________________________, son / daughter / wife of ______________________________Permanent resident of_________________________, Village / Street ______________________Post Office____________________District in the State / Union Territory _________________Pin Code____________whose photograph is attested below belongs to Economically Weaker Sections, since the gross annual income* of his / her family** is below Rs. 8 lakh (Rupees Eight Lakh only) for the financial year___________. His / her family does not own or possess any of the following assets***:**

   I. 5 acres of agricultural land and above;
   II. Residential flat of 1000 sq. ft. and above;
   III. Residential plot of 100 sq. yards and above in notified municipalities;
   IV. Residential plot of 200 sq. yards and above in. areas other than the notified municipalities.

2. **Shri / Smt. / Kumari___________________________________belongs to______________________the caste which is not recognized as a Scheduled Caste, Scheduled Tribe and Other Backward Classes (Central List).s**

Signature with seal of Office_____________________

Name____

Designation___________________________________

Recent Passport size attested photograph of the applicant

The income and assets of the families as mentioned would be required to be certified by an officer not below the rank of Tehsildar in the States/UTs.

Note:

* Income covered all sources i.e. salary, agriculture, business, profession,etc.

** The term “Family" for this purpose includes the person, who seeks benefit of reservation, his/her parents and siblings below the age of 18 years as also his/her spouse and children below the age of I8 years.

*** The property held by a "Family' in different locations or different places/cities have been clubbed while applying the land or property holding test to determine EWS status.

FORMAT FOR SC/ST CERTIFICATE

A candidate who claims to belong to one of the Scheduled Castes or the Scheduled Tribes should submit in support of his claim an attested / self-certified copy of a certificate in the form given below, from the District Officer or the Sub-Divisional Officer or any other officer as indicated below of the District in which his parents (or surviving parent) ordinarily reside who has been designated by the State Government concerned as competent to issue such a certificate. If both his parents are dead, the officer signing the certificate should be of the district in which the candidate himself ordinarily resides otherwise than for the purpose of his own education. Wherever photograph his integral part of the certificate, the NIT Durgapur would accept only attested/self-certified photocopies of such certificates and not any other copy.

This is to certify that Shri / Shrimati / Kumari*____

_____________________________________Son / daughter of__________________________________

_____________________________________of village /t own/*______________________________in

District/Division*________________________of the State /Union Territory* __________________

_____________________________________belongs to the__________________________________Caste/

Tribe* which is recognized as a Scheduled Castes [SC]*

/ Scheduled Tribes [ST]* under:

The Constitution (Scheduled Castes) Order, 1950 The

Constitution (Scheduled Tribes) Order, 1950

The Constitution (Scheduled Castes) Union Territories Order, 1951 The

Constitution (Scheduled Tribes) Union Territories Order, 1951

As amended by the Scheduled Castes and Scheduled Tribes Lists (Modification) Order, 1956, the Bombay Reorganization Act, 1960 & the Punjab Reorganization Act, 1966, the State of Himachal Pradesh Act 1970, the North-Eastern Area (Reorganization) Act, 1971 and the Scheduled Castes and Scheduled Tribes Order (Amendment) Act, 1976. [**%**]

The Constitution (Jammu & Kashmir) Scheduled Castes Order, 1956. The Constitution (Andaman and Nicobar Islands) Scheduled Tribes Order, 1959 as amended by the Scheduled Castes and Scheduled Tribes Order (Amendment Act), 1976. The Constitution (Dadra and Nagar Haveli) Scheduled Castes Order, 1962. The Constitution (Dadra and Nagar Haveli) Scheduled Tribes Order 1962**. The Constitution (Pondicherry) Scheduled Castes Order, 1964**. The Constitution (Scheduled Tribes) (Uttar Pradesh) Order, 1967**.The Constitution (Goa, Daman & Diu)ScheduledCastesOrder,1968**. The Constitution (Goa, Daman & Diu) Scheduled Tribes Order, 1968**. The Constitution (Nagaland) Scheduled Tribes Order,1970**. The Constitution (Sikkim) Scheduled Castes Order, 1978**.[%]

The Constitution (Sikkim) Scheduled Tribes Order, 1978**. The Constitution (Jammu & Kashmir) Scheduled Tribes Order 1989**. The Constitution (SC) Orders (Amendment) Act, 1990**. The Constitution (ST) Orders (Amendment) Ordinance, 1991**. The Constitution (ST) Orders (Second Amendment) Act,1991**.The Constitution (ST) orders (Amendment) Ordinance,1996. The Scheduled Caste and Scheduled Tribe Orders (Amendment) Act. 2002. The Constitution (Scheduled Caste) Orders (Amendment) Act, 2002. The Constitution (Scheduled Caste and Scheduled Tribe) Orders (Amendment) Act, 2002. The Constitution (Scheduled Caste) Order (Amendment) Act, 2007.[**%**]

2. Applicable in the case of Scheduled Castes, Scheduled Tribes persons who have migrated from one State / Union Territory Administration.

This certificate is issued on the basis of the Scheduled Castes / Scheduled Tribes certificate issued to Shri / Shrimati__________________________, Father / Mother of Shri / Srimati/ Kumari* -- of village / town* ----------------------------------- in the District / Division* -- of the State / Union Territory* --- who belong to the -- Caste / Tribe* which is recognized as a Scheduled Caste* Scheduled Tribe* in the State / Union Territory* issued by the --- dated-- ***

3. Shri / Shrimati / Kumari*____and/or* his/her* family ordinarily reside(s) in the village/town*____of ______________________________District / Division* of the State / Union Territory of _____________________________.

Place_____________________ **Signature**_____________________________

Date_________________ **Designation**___________________________

(with seal of office)

*** Please delete the words which are not applicable**

**** Please quote specific presidential order**

***** please delete the paragraph which is not applicable.**

^ List of authorities empowered to issue Schedule Caste / Schedule Tribe Certificates:

1) District Magistrate / Additional District Magistrate / Collector / Deputy Commissioner / Additional Deputy Commissioner / Deputy Collector / 1st Class Stipendiary Magistrate / Sub-Divisional Magistrate / Addl. Assistant Commissioner / Taluka Magistrate / Executive Magistrate and equivalent as per GOI orders.
2) Chief Presidency Magistrate / Additional Chief Presidency Magistrate / Presidency Magistrate.
3) Revenue Officers not below the rank of Tehsildar.
4) Sub-Divisional Officers of the area where the candidate and /or his/her family normally resides.

NOTES:

1) The term ordinarily reside(s) used here will have the same meaning as in Section 20 of the Representation of the People Act, 1950.

2) ST candidates belonging to Tamil Nadu state should submit caste certificate only from the Revenue Divisional Officer.

DISABILITY CERTIFICATE FORMAT- II

{In cases of amputation or complete permanent paralysis of limbs and in cases of blindness}

(NAME AND ADDRESS OF THE MEDICAL AUTHORITY ISSUING THE CERTIFICATE)

No.-__________________________________ **Date-**_________/________/_______________

Passport size photograph of the candidate

Signature /LTI / RTI of the Candidate

This is to certify that I have carefully examined Shri /Smt./Kum.____,

Son / wife / daughter of Shri_____________________________________Date of Birth______/______/______________

[Age-__________years], male/female.____permanent resident of

House No.- ____________, Ward/Village/Street ______________________________Post Office

________________________District____________________________State___________________________,whose

photograph is affixed above, and am satisfied that

1. he/she is a case of (Please tick as applicable):
   a. locomotor disability
   b. blindness
2. The diagnosis in his/her case is____.
3. He / She has_______________% (in figure)_____________________________________percent (in words) permanent physical impairment / blindness in relation to his / her _______________________________________ (part of body) as per guidelines (to bespecified).
4. The applicant has submitted the following document as proof of residence:-

Nature of Document	Date of Issue	Details of authority issuing the certificate

Official Seal:

[Authorized Signatory of notified Medical Authority]

Name: ____

DISABILITY CERTIFICATE FORMAT - III

{In cases of multiple disabilities}

(NAME AND ADDRESS OF THE MEDICAL AUTHORITY ISSUING THE CERTIFICATE)

No.-____________________________________ **Date-**_________/_________/________________

Signature / LTI / RTI of the Candidate

Passport size photograph of the candidate

This is to certify that I have carefully examined Shri / Smt./ Kum.____,

Son /wife/daughter of Shri____Date of Birth_______/______/_______________

[Age-___________years], male / female____Permanent resident of

House No.- _____________, Ward / Village / Street ________________________________Post Office

___________________________District______________________________State_____________________________,whose

photograph is affixed above, and am satisfied that

1. He/she is a Case of **Multiple Disability.** His/her extent of permanent physical impairment/ disability has been evaluated as per guidelines (to be specified) for the disabilities ticked below, and shown against the relevant disability in the table below:

S. No.	Disability	Affected Part of Body	Diagnosis	Permanent physical impairment/mental disability (in percentage)
1	Locomotor disability	@		
2	Low vision	#		
3	Blindness	Both Eyes		
4	Hearing impairment	£		
5	Mental retardation	X		
6	Mental-illness	X		

Contd.

2. In the light of the above, his / her overall permanent physical impairment as per guidelines (to be specified), is as follows:

In figures:____________________________%

In words:____percent

3. The above condition is progressive / non-progressive / likely to improve / not likely to improve.

4. Reassessment of disability is:

(i) Not Necessary **[or]**

(ii) Is recommended / after____________years___________months, and therefore this certificate shall be valid till (DD/MM/YY)_________________________.

@ - e.g. Left / Right/both arms/ l arms/legs
 # - e.g. single eye / both eyes
£- e.g. Left / Right / both ears

5. The applicant has submitted the following document as proof of residence:

Nature of Document	Date of Issue	Details of authority issuing the certificate

6. Signature and seal of the Medical Authority:

Name and Seal of Member	**Name of Seal of Member**	**Name and Seal of the Chairperson**

DISABILITY CERTIFICATE FORMAT - IV

{In cases of any other case not covered in Format – II & III}

(NAME AND ADDRESS OF THE MEDICAL AUTHORITY ISSUING THE CERTIFICATE)

No.-___________________________________ **Date-**_________/________/_______________

Passport size photograph of the candidate

Signature/LTI/RTI of the Candidate

This is to certify that I have carefully examined Shri/Smt./Kum.____,

Son /wife/daughter of Shri_______________________________________Date of Birth_______/______/______________

[Age-__________years], male / female____permanent resident of

House No.- _____________, Ward / Village / Street _______________________________Post Office

_________________________District_____________________________State___________________________,whose

photograph is affixed above, and am satisfied that

1. He/she is a Case of **Multiple Disability.** His / her extent of permanent physical impairment/ disability has been evaluated as per guidelines (to be specified) for the disabilities ticked below, and shown against the relevant disability in the table below:

S. No.	Disability	Affected Part of Body	Diagnosis	Permanent physical impairment/mental disability (in percentage)
1	Locomotor disability	@		
2	Low vision	#		
3	Blindness	Both Eyes		
4	Hearing impairment	£		
5	Mental retardation	X		
6	Mental-illness	X		

Contd.

2. In the light of the above, his/her overall permanent physical impairment as per guidelines (to be specified), is as follows:

In figures:____________________________%

In words:____percent

3. The above condition is progressive / non-progressive / likely to improve /not likely to improve.

4. Reassessment of disability is:

(i) Not Necessary **[or]**

(ii) Is recommended/after_____________years___________months, and therefore this certificate shall be valid till (DD/MM/YY)_________________________.

@ - e.g. Left / Right/both arms/ l arms/legs
 # - e.g. single eye / both eyes
£- e.g. Left / Right / both ears

5. The applicant has submitted the following document as proof of residence:

Nature of Document	Date of Issue	Details of authority issuing the certificate

Official Seal:

[Authorized Signatory of notified Medical Authority*]

Name:____

* In case this certificate is issued by a medical authority who is not a government servant, it shall be valid only if countersigned by the Chief Medical Officer of the District. Note: The principal rules were published in the Gazette of India vide notification number S.O. 908(E), dated the 31st December, 1996.

Countersigned

Official Seal:

[CMO / Medical Superintendent / Head of Govt. Hospital]

Name:___________________________________

^ Counter signature and seal of the CMO/Medical Superintendent / Head of Government Hospital is essential in case the certificate is issued by a medical authority who is not a government servant.

FORMAT FOR DYSLEXIA CERTIFICATE - I

MEDICAL CERTIFICATE TO BE PRODUCED BY DYSLEXIC CANDIDATES

{Psycho-Education Evaluation Report - To be obtained from any Dyslexia Association*}

No.-_________________________________ **Date-**_________/________/_______________

Passport size photograph of the Candidate

Name of the candidate:____

Date of Birth:______/________/__________

Name of the Father / Mother/ Guardian____

Registration in the Dyslexia Association: No_____________________________

Date-_______/________/__________

Name & Address of the Dyslexia Association:____

____

Registration No. of the Dyslexia Association:____

Physical & Neurologic Assessment: [ ]

Psychological Assessment: [ ] WISC

Verbal IQ:

Performance IQ:

Full Scale IQ:

Interpretation: [ ]

Educational Assessment: [

Certified that

The condition of handicap is: MILD / MODERATE / SEVERE (tick whichever is applicable)**
The disability is **PERMANENT** in nature.

*Some Dyslexia Associations:

1) Dyslexia Trust of Kolkatta, Divya Jalan, Aruna Bhaskar 3, Dover Park, Kolkata –700019
2) Dyslexia Association Of Andhra Pradesh(DAAP), 34494/1, 1st Floor, Macherla Gastrology Hospital, Reddy College Road, Barkatpura,Hyderabad,Telangana,500027
3) Madras Dyslexia Association,94 Park View, 1st Floor,G.N.ChettyRoad,T.Nagar,Chennai–600017, Maharashtra Dyslexia Association, 003, Amit Park Bldg, L J Road, Deonar, Mumbai 400088
4) The Dyslexia Association of India,MZ-47,TheCenter Stage Mall, Plot No 01, Block L, Sector 18,NOIDA201303

**Learning Disability is a permanent developmental disorder. Currently there are no standard approved methods to quantify the disorder. However the method of diagnosis is based on significant impairment in academic achievement. To avail the benefit of relaxed norm under PwD category, the candidate must come under SEVERE category.

Official Seal:

[Signature]

Name of the certifying official:___________________________

FORMAT FOR DYSLEXIA CERTIFICATE - II

TESTIMONIAL TO BE PRODUCED BY DYSLEXIC CANDIDATES

{Testimonial - To be obtained from the Principal of the school/college last attended*}

No.-____________________________________ **Date-**_________/_________/__________

Name of the candidate:____

Passport size photograph of the Candidate

Date of Birth:______/_______/________

Name of the Father/ Mother/Guardian___________________________________

Registration in the Dyslexia Association: No_________________________

Date-______/_______/________

Name & Address of the School/College:____

____

Certified that

Shri /Shrimati / Kumari____

Son / daughter of____of

_____________________________Village / Town passed his/her Class X from this school and as per records, he / she has availed concession under dyslexic category.

Official Seal:

[Signature]

Name of the Principal:___________________________________

*A candidate passing Class X or equivalent through open school system or in private mode may submit the certificate to this effect from the competent authority in the board certifying the concessions availed under dyslexia.

FORMAT OF COURSE COMPLETION CERIFICATE

[TO BE ISSUED IN THE OFFICIAL LETER HEAD OF THE INSTITUTE/UNIVERSITY]

This is to certify that

1. Mr./Ms.____(full name) bearing

   Roll No._____________is a registered student of___________________(course / program) in our institute/university.

2. He / She has completed all requirements of the course / program and all of his/her examinations likely to be completed by August 15, 2022.

3. His / Her final result is awaited and will be published on or before September 30, 2022.

____

Signature (with Seal) of the
Authorised Signatory of the
Institute/University

Date- ___________________

FORMAT OF SELF DECLARATION ABOUT COURSE COMPLETION

I…………………………………D/o / S/o Shri ………………….…………… R/o ………………

do hereby declare on oath as under:

1. That I am a registered student of .... Course/Programme in Institute/University…………………………..………with Enrollment no…………………….
2. That I am in final year of the aforesaid course/programme and have completed all the requirements of the course / programme which was to be completed upto ....2022. But due to COVID-19 Pandemic, the Institute /University could not conduct the final examination of said course / programme which is likely to be completed by ....2022.
3. That I will submit my degree/provisional certificate issued by the Institute/University upto 30th September, 2022 / 15 days after result declaration of the institute where I am studying / the date as given by the admitting institute/Govt. of India notification, failing which I understand that my admission in PhD Programme may be cancelled.
4. That I further understand that if I am unable to qualify the minimum eligibility criterion for admission to PhD Programme, my admission will stand cancelled and the admitting Institution shall have no liability for the same.

Signature of the Candidate:

Name:

Date:

FORMAT OF SELF DECLARATION ABOUT NON AVAIBILITY OF PREFINAL YEAR / SEMESTER MARKSHEET

I…………………………………D/o / S/o Shri ……………………….…………… R/o ……………………….

do hereby declare on oath as under:

1. That I am a registered student of ………………………………Course/ Programme in Institute / University………………………..………with Enrollment no……………………………………...

2. That I have completed all the requirements of the courses of pre final year and do not have any backlogs. But due to COVID-19 Pandemic, the mark sheet of pre final year / semester has not been issued by the Institute/University.

3. I undertake that I will submit my mark sheet(s) of all years/semesters along with provisional/degree certificate issued by the Institute/University within the time limit specified by my finally allotted institute, failing which I understand that my admission in Ph. D Programme may be cancelled.

4. That I further understand that if I am unable to qualify the minimum eligibility criterion for admission to Ph. D Programme, my admission will stand cancelled and the admitting Institution shall have no liability for the same.

5. Any misinformation/ wrong information furnished will lead to cancellation of admission and fees deposited will be forfeited.

Signature of the Candidate in full:

Name:

Date:

FORMAT OF SELF DECLARATION ABOUT NON AVAIBILITY OF PROVISIONAL / DEGREE CERTIFICATE

I…………………………………D/o / S/o Shri ………………….…………… R/o ………………

do hereby declare on oath as under:

1. That I am a registered student of ………………………………Course/Programme in Institute / University………………………..………with Enrollment no…………………….

2. That I have completed all the requirements of the course/programme for the award of degree and do not have any backlogs. But due to COVID-19 Pandemic, the provisional/degree certificate has not been issued by the Institute/University.

3. I undertake that I will submit my degree/provisional certificate issued by the Institute/University within the time limit specified by my admitting institute, failing which I understand that my admission in PhD Programme may be cancelled.

4. That I further understand that if I am unable to qualify the minimum eligibility criterion for admission to Ph.D Programme, my admission will stand cancelled and the admitting Institution shall have no liability for the same.

5. Any misinformation/ wrong information furnished will lead to cancellation of admission and fees deposited will be forfeited.

Signature of the Candidate:

Name:

Date:

UNDERTAKING FOR CASTE VALIDITY CERTIFICATE FOR MAHARASHTRA STATE CANDIDATES

To,

The Verifying Centre In-charge / Dean (Academic Research) /Head of the Department

NIT Durgapur

Subject: Undertaking for Caste Validity Certificate

Respected Sir,

I_______________________________________S/o/D/o_______________________________________

R/o_____________________________________ has been selected / allotted seat in Ph. D Admission 2022 (Name of the Institute)___________________________________I have not submitted my Caste Validity Certificate as I am not in receipt of the same till date. I have applied for the Caste Validity Certificate to Social welfare Department/ Tribal Welfare Department on ________________________________(Date).

I herewith give the undertaking that I will submit the Caste Validity Certificate issued by competent authority at the time of physical reporting. I hereby declare that my application for the Caste Validity Certificate is under process and has not yet been rejected. In case I fail to submit the Caste Validity Certificate by the date as mentioned above or found ineligible or information provided herein or in Application Form found incorrect at any stage then the Institute reserves the right to cancel my admission automatically. In such event, I shall be fully responsible for all consequences arising out of such cancellation of admission. (Name of the Institute)________________________________shall not be held responsible in any case. I also understand that, fee refund rules of (Name of the Institute)________________________________will be applicable in case of cancellation of my admission.

Signature of the Candidate

Signature of Guardian /Parents

Name of the Candidate

Name of the Guardian /Parents

Date:___________________

Date:_________________

Undertaking to be submitted by GEN-EWS Candidates, not having the GEN-EWS certificate issued on or after 1st April 2022

(To be given on Non-Judicial Stamp Paper of minimum Rs. 20/- and duly notarized)

I,____(Name of candidate)

S/D/O________________________________resident of____________________

do hereby solemnly affirm and state as follows:

1. That, I know that the GEN-EWS certificate required for NIT Durgapur PhD Admission 2022 should be issued on or after 1st April 2022.
2. That, due to Covid-19 lockdown, I could not get the required GEN-EWS certificate issued after 1st April 2022.
3. That, I am availing the temporary relaxation by the institute due to Covid-19.
4. That, I am fully aware that the GEN-EWS certificate issued on or after 1st April 2022 will be required at the time of admission at NIT Durgapur.
5. That, I am fully aware that at the time of admission, if I could not submit the required GEN-EWS certificate issued on or after 1st April 2022, my admission may be cancelled and I will not have any claim on the admission at NIT Durgapur.
6. That, if my admission is cancelled, the refund, if any, will be dealt as per Refund Rules of the institute.

I declare that I belong to Economically Weaker Sections, since the gross annual income of my family is below Rs. 8 lakh (Rupees Eight Lakh only) for the financial year 2021-22. I also declare that my family does not own or possess any of the following assets:

I. 5 acres of agricultural land and above;
II. Residential flat of 1000 sq. ft. and above;
III. Residential plot of 100 sq. yards and above in notified municipalities;
IV. Residential plot of 200 sq. yards and above in. areas other than the notified municipalities.

Hence, I declare that I fulfill all the requirements for issuing of EWS certificate to me on or after 1st April, 2022.

Place:____________

Date:______________

____

Signature of the Candidate

Note: If the candidate does not have EWS certificate issued on or after 1st April, 2022, then she/he may upload this affidavit along with the proof of application submitted for issue of the EWS certificate and any older certificate, if available.

Undertaking to be submitted by OBC-NCL Candidates, not having the OBC-NCL certificate issued on or after 1st April, 2022

(To be given on Non-Judicial Stamp Paper of minimum Rs. 20/- and duly notarized)

I,____(Name of candidate) S/D/O________________________of Village / Town _____________________________ District / Division____________________________in the______________________ _____________________________State / UT belongs to the______________________ _____________________________Community which is listed in Central List of OBCs category available at website: http://www.ncbc.nic.in and I do hereby solemnly affirm and state asfollows:

1. That, I know that the OBC-NCL certificate required for NIT Durgapur PhD Admission-2022 should be issued on or after 1st April 2022.
2. That, due to Covid-19 lockdown, I could not get the required OBC-NCL certificate issued after 1st April 2022.
3. That, I am availing the temporary relaxation by the institute due to Covid-19.
4. That, I am fully aware that the OBC-NCL certificate issued on or after 1st April 2022 will be required at the time of admission at the Institute.
5. That, I am fully aware that at the time of admission, if I could not submit the required OBC-NCL certificate issued on or after 1st April 2022, my admission may be cancelled and I will not have any claim on the admission at NIT Durgapur.
6. That, if my admission is cancelled, the refund, if any, will be dealt as per Refund Rules of the institute.

It is also declared that I do not belong to persons/sections (Creamy Layer) mentioned in Column 3 of the Schedule to the above referred Office Memorandum, dated 8/9/1993, which is modified vide Department of Personnel and Training Office Memorandum No.36033/3/2004 Estt.(Res.) dated 9/3/2004. I also declare that the condition of status/annual income for creamy layer of my parents/guardian is within prescribed limits as on financial year ending on March 31, 2022.

Hence, I declare that I fulfill all the requirements for issuing of OBC-NCL certificate to me on or after 1st April, 2022.

Place:___________

Date:____________

Signature of the Candidate

Note: If the candidate does not have OBC-NCL certificate issued on or after 1st April, 2022, then she/he may upload this affidavit along with the proof of application submitted for issue of the OBC-NCL certificate and any older certificate, if available.

(TO BE PRINTED ON THE LETTER HEAD OF THE HEAD OF THE INSTITUTION / COMPANY)

No. xxxx Date: xx/xx/xxxx

No Objection Certificate for Professional PhD

With reference to your Advt. No. _________________________, dated__________, xx/xx/xxxx the Head of the Institution / Company is pleased to permit Mr. / Mrs. /Miss. ------------------------------------ to pursue his / her Ph.D. program (Part-time) at National Institute of Technology Durgapur from the day of issuance of this letter for a period of three / four / five Years. Mr. / Mrs. /Miss. ------------------------------------ will be allowed to attend regular classes as per the requirement of the part-time PhD program of NIT Durgapur for the course he / she is admitted.

Sincerely Yours,

(Head of the Institute / Company)

(Seal)

(To be printed on the letterhead of the Institute)

No. xxxx **Date: xx/xx/xxxx**

No Objection Certificate from NIT Durgapur

This is to certify that Mr./Ms. ____ s/o ____has joined the Department / Section of ____ as a _________________________(specify designation) on dd/mm/yyyy in NIT Durgapur. I have no objection if he / she applies for and eventually, secures a PhD admission with respect to *Advt. No.* ___________________________, dated_______________________.

(Signature of Competent Authority)

Designation

Seal & Date

(TO BE PRINTED ON THE LETTERHEAD OF THE PRINCIPAL INVESTIGATOR/PROPOSED SUPERVISOR)
&
FORWARDED BY THE OFFICE OF DEAN (R &C))

No. xxxx **Date: xx/xx/xxxx**

NO OBJECTION CERTIFICATE

(Applicable for candidates who are applying under the **CATEGORY C** and who are already engaged as JRF/SRF/others in any externally funded (Govt./Company/Others) Sponsored Projects in the Institute)

This is to certify that Mr./Ms. ____ S/o or D/o ____has joined a project entitled "____", which is funded by ____ as a JRF/SRF/Others (specify) ______________________________ on dd/mm/yyyy in the Department/Centre_____________________of NIT Durgapur.

The completion date of this project is dd/mm/yyyy___________.

I have no objection, if he/she applies for and eventually secures a PhD admission with respect to **Advt. No.**_____________________________, dated __________.

I shall be happy to supervise this candidate for his/her PhD.

Yours sincerely,

(**Name & Signature of the Principal Investigator**)

Project Seal & Date

Forwarded by

(HOD/Centre Coordinator)

Forwarded by

(Dean (R & C))

(TO BE PRINTED ON THE LETTERHEAD OF THE PROPOSED SUPERVISOR)

No. xxxx **Date: xx/xx/xxxx**

NO OBJECTION CERTIFICATE

(Applicable for candidates who are applying under the **CATEGORY B** and who have financial support/scholarship from Government Programs (sponsored by DST, CSIR, UGC, DST-INSPIRE, etc.) to carry out research studies as Regular Research Scholar)

This is to certify that Mr./Ms. ____ S/o or D/o ____has obtained a fellowship under the scheme "____", which is funded by ____ as a JRF/SRF/Others (specify) __________________________ on dd/mm/yyyy in the Department/Centre ___________________of NIT Durgapur. The said fellowship will be available till dd/mm/yyyy.

I have no objection, if he/she applies for and eventually secures a PhD admission with respect to the **Advt. No.**______________________, dated ________________.

I shall be happy to supervise this candidate for his/her PhD.

Yours sincerely,

(**Name of the Proposed Supervisor**)
Department/Centre:
Stamp & Date

Sponsorship Certificate for Ph.D. Programme

(A sponsored candidate must furnish this certificate along with the application form, printed on the letterhead of the organization)

Certified that Mr./Ms.______________________________________an applicant selected for admission to the PhD programme in the Department ____________________________________of the National Institute of Technology, Durgapur in the _______(Odd/Even) Sem. of the Session _______-________ is employed with our organization named____and that he/she will be sponsored by us for undergoing the Ph.D. programme. The following are the relevant particulars, related to him / her:

(1) Date of joining with the organization:____

(2) Present Designation___________________________________Nature of duty_____________________

(3) Present place of posting____

(4) Period of sponsorship granted, from___________________________to__________________________

(5) Date of being relieved of duties to join the programme in the Institute___________________________

(6) Total period of leave granted by the organization____________Year_________Months_______Days for undergoing the programme (Residential requirement)

(7) In the case of candidates who intend to apply, after academic registration in the Institute, for permission to work externally at the place of employment whether:

(a) Necessary research facilities are available in the organization_________________________________

(b) The organization agrees to provide him/her those facilities__________________________________

(c) Name & Designation of the expert in the organization can guide partly research work in this case if necessary(with a brief bio-data)____

____

____

____

Certified further that his/her services with the Organization will be retained during the period he/ she carries out the studies / research work at NIT Durgapur and on completion thereof he /she will be accepted for joining back. It has been noted that for the sponsored students /scholars the NIT Durgapur does not have any financial commitment whatsoever and all necessary expenses for his/ her study will be borne by the Organization.

Date________________ Signature of Competent Authority____________________

Full Name :__________________________________

Designation :__________________________________

Official Stamp :__________________________________

Name & Designation of the expert in the organization can guide partly research work in this case if necessary (with a brief bio-data)____

N.B.: Please strike out the items not applicable. All the columns must be filled in; otherwise the Sponsorship Certificate will not be acceptable.

No. xxxx **Date: xx/xx/xxxx**

DECLARATION
FOR
CATEGORY K
(REGULAR RESEARCH SCHOLAR WITHOUT INSTITUTE FELLOWSHIP (SELF-SPONSORED))
FOR
UNEMPLOYED/SELF-EMPLOYED CANDIDATES

I, ________________________________, Son/Daughter of ____________________, Address: ____do hereby declare that I am unemployed/self-employed (tick any one, whichever is applicable) candidate and I am willing to pursue Ph.D. program **(Self-Sponsored)** at the Department/Centre of___________________________, National Institute of Technology Durgapur with reference to your Advt. No. ______________________, dated ___________, (xx/xx/xxxx).

I will attend regular classes and I will carry out research activities regularly. I agreed to pay all the Institute fees for the entire duration of the PhD program regularly and fulfill all other requirements of PhD program (self-sponsored) as per PhD regulations of the Institute.

(Name of the Applicant)
Name of the Organization/Company (for self-employed candidate, if any):
Address with contact details:
Designation:________________________Since________________________

(TO BE PRINTED ON THE LETTER HEAD OF THE HEAD OF THE INSTITUTION/ COMPANY)

No.xxxx Date: xx/xx/xxxx

NO OBJECTION CERTIFICATE
FOR
CATEGORY K
(REGULAR RESEARCH SCHOLAR WITHOUT INSTITUTE FELLOWSHIP (SELF-SPONSORED))
FOR EMPLOYED CANDIDATES

The applicant Mr./Mrs./Miss ______________________________, Son/Daughter of ____________________, is a permanent employee (Emp. Code____________) of ____________________________ (name of the organization) and holding the position/post ___________(designation) since _________to__________, with reference to your Advt. No. _____________________dated ____________ (xx/xx/xxxx), the Head of the Institution/Company is pleased to permit
Mr./Mrs./Miss ____
to pursue his/her PhD programme (self-sponsored) at the Department/Centre_________________of National Institute of Technology, Durgapur from the day of issuance of this letter for a period of three/four/five years.
Mr./Mrs./Miss ___________________________________ will be allowed to attend regular classes as per the requirement of the Ph.D. regulation of the Institute for the Self-sponsored Ph.D. programme of NIT Durgapur for the course he/she is admitted.

Sincerely Yours,

(Head of the Institute/Company)

(Seal)

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Academic Section

ANNEXURE 67.5.2

Date: 07.09.2022

Minutes of the meeting of Research Academic Committee (RAC) held on 07.09.2022 (Wednesday) at 03.30 pm.

The Chairman welcomed the members to the meeting and the agenda was placed for discussion.

Item # 1 Confirmation of the minutes of the meeting of RAC held on 08.06.2022.

The minutes of the RAC meeting held on 08.06.2022 are confirmed.

Item # 2 To consider registration for Ph.D. Programme

SL. NO	ROLL NO.	NAME	DEPT	COURSE WORK (TOTAL CREDIT)			NAME OF THE SUPERVISOR(S)	DATE OF REG.
				ASGN. BY DSC	AS PER REGULATION	COMPLETED		
1	~~20BT1110~~	~~Subhajit Dutta~~	~~BT~~	~~16~~	~~16~~	~~16~~	~~Dr. D. De~~	~~09.05.2022~~
2	19ME1502	Bikramjit Mukherjee	ME	20	20	20	Dr. A. Layek	10.06.2022
3	19CS1109	Manvendra Singh	CS	19	16	19	Dr. A. Sharma	14.06.2022
4	21CS1501	Arunita Das	CS	16	8	16	Dr. A. Dutta	17.06.2022
5	20CS1502	Kankana Datta	CS	20	20	20	Dr. M. Dalui Dr. B. Jana, Vidyasagar University	22.06.2022
6	20CH1101	Rwiddhi Sarkhel	CH	8	8	8	Dr. P. Gupta Dr. T. Mandal	23.06.2022
7	20MM1501	Abdur Rouf	MM	16	16	16	Dr. M. Mallik Dr. K. P. Yagati	28.06.2022
8	20MM1106	Sayandip Sarkar	MM	8	8	8	Dr. M. Mallik Dr. M. K. Mondal	28.06.2022
9	21MM1101	Anirban Hazra	MM	8	8	8	Dr. M. Mallik	28.06.2022
10	18BT1103	Rohan Harsh Jadhav	BT	16	16	16	Dr. A. Dey	29.06.2022
11	21EE1109	Subhash Chandra Paul	EE	10	8	14	Dr. A. K. Dhara Dr. R. Strand, CIA, Uppsala, Sweden	30.06.2022
12	21EE1110	Swagata Kundu	EE	10	8	14	Dr. A. K. Dhara Dr. R. Strand, CIA, Uppsala, Sweden	30.06.2022

RK

13	19BT1113	Reshmi Verma	BT	16	16	16	Dr. K. Aikat	04.07.2022
14	20ME1108	Tuhin Kar	ME	8	8	8	Dr. A. Goswami	04.07.2022
15	20BT1109	Abhishek Verma	BT	20	20	20	Dr. D. Dasgupta Mandal	06.07.2022
16	18EC1106	Rajrup Saha	EC	12	12	12	Dr. D. Mandal Dr. R. Kar	07.07.2022
17	20MM1102	Md Imran Rizwi	MM	8	8	8	Dr. B. K. Show Dr. D. Mandal	13.07.2022
18	20MM1101	Amar Mahato	MM	8	8	8	Dr. S. Bera Dr. B. K. Show	13.07.2022
19	20BT1107	Sindhuja. R	BT	8	8	8	Dr. D. De	18.07.2022
20	20BT1111	Arghyadeep Bhattacharjee	BT	20	20	20	Dr. O. Mukherjee	19.07.2022
21	20PH1101	Parthasarathi Sahu	PH	20	16	20	Dr. H. Subramanian	21.07.2022
22	20CS1102	Sukanya Maji	CS	15	12	15	Dr. S. Sadhu	04.08.2022
23	20CS1105	Poulomi Mukherjee	CS	22	20	22	Dr. T. De	04.08.2022
24	21CS1108	Subashis Karmakar	CS	10	9	16	Dr. T. Pal Dr. C. Koley	08.08.2022
25	20MS1103	Keshav Kant Prasad	MS	16	16	21	Dr. A. Ghosh	10.08.2022
26	20MS1104	Divya Singh	MS	16	16	27	Dr. U. K. Paul	17.08.2022
27	21PH1503	Suresh Das	PH	16	16	20	Dr. S. Ghosh	24.08.2022
28	20PH1103	Dibyajyoti Mallick	PH	16	16	20	Dr. S. Ghosh	24.08.2022
29	20EC1104	Suman Biswas	EC	8	8	12	Dr. G. K. Mahanti Dr. N. Chattaraj	25.08.2022
30	20CH1102	Sayantan Adak	CH	8	8	8	Dr. M. K. Mandal Dr. R. G. Chaudhuri	30.08.2022

The registration to the PhD programme of the above mentioned scholars are recommended for approval on the dates as mentioned against the respective scholars.

Item # 3 **To consider the name of the students to be awarded with Ph.D. Degree** –completed all requirements for the award of Ph.D. Degree.

SL. NO	REGN. NO	DEPT.	NAME OF THE SCHOLAR	TITLE OF THE THESIS	NAME OF THE SUPERVISOR(S)	DATE OF AWARD
1	NITD/PhD/HS/2018/01067	HS	Kabita Mondal	Foregrounding Social, Moral and Psychodynamic Perspectives of Empathy: A Critical Study of Select Indian Graphic Narratives	Dr. J. Banerjee	27.05.2022
2	NITD/PhD/MS/2013/00454	MS	Sujata Bose	A Study on Workplace Adaptability: An Indian Perspective	Dr. D. Pal	31.05.2022

3	NITD/PhD/MA /2016/00820	MA	Sukhendu Bera	Mathematical Models of Some Decision Making Problems in Uncertain Environments	Dr. K. Basu Dr. D. K. Jana HIT, Haldia Dr. M. Maiti Vidyasagar University	10.06.2022
4	20RMA001	MA	Saikat Roy	Birkhoff-James Orthogonality in the Geometry of Banach Spaces and Some Related Topics	Dr. S. Bagchi	22.06.2022
5	NITD/PhD/MS /2018/01077	MS	Avijit Sarkar	Strategy for Dairy Development in West Bengal, India	Dr. Avijan Dutta	27.06.2022
6	NITD/PhD/ChE / 2014/00468	CH	Manish Chandra Kannaujiya	Development of a suitable treatment system for hazardous Leather Industry dye (Acid Yellow 2GL) removal from simulated wastewater	Dr. T. Mandal Dr. M. K. Mondal, IIT BHU Dr. A. K. Das MAKAUT, W.B.	27.06.2022
7	19RCH005	CH	Wasi Ur Rahman	Experimental Investigation on Catalytic Transesterification of Natural Feedstocks towards Biodiesel Production	Dr. G. Halder	30.06.2022
8	19RMA031	MA	Ashis Bera	Results on some contractions and nonexpansive mappings with applications	Dr. L. K. Dey	18.07.2022
9	NITD/PhD/PH / 2015/00595	PH	Hrishikesh Mondal	Studies on Ring Oscillator and its Applications in Communication Systems	Dr. M. K. Mandal	21.07.2022
10	19RCH015	CH	Bisheswar Karmakar	Biodiesel Production from Non- Edible and Waste oils through Catalyzed and Superheated Uncatalyzed Approaches	Dr. G. Halder	22.07.2022
11	NITD/PhD/HS/ 2018/01016	HS	Sourav Paul	Secularism and Islam: Friction in the Post 9/11 Fictionsby Muslim Writers	Dr. S. K. Rai	27.07.2022
12	NITD/PhD/MM /2018/01023	MM	Ritwik Das	Study on the Mechanical Working of Blast Furnace Flue Dust – Iron Oxide – Graphite Composite Briquette Made with Fly Ash as a Binder	Dr. S. Pramanik Dr. M. K. Mondal	28.07.2022

PK

13	NITD/PhD/CY/ 2017/00923	CY	Sourav Chatterjee	Chemistry of Various p and d Block Metal Complexes of Schiff bases Having Different N, O Donor Sites: Catalytic and Sensor Applications	Dr. D. Sukul Dr. P. Banerjee, CMERI Durgapur Dr. T. Chattopadhyay DHWU, Sarisha	28.07.2022
14	NITD/PhD/CS/ 2017/00934	CS	Soma Debnath	A Deep Learning Appro ach to Recognize the Compositional Aspect o f Different Lines and Sha pes in a Photograph	Dr. S. Changder	29.07.2022
15	NITD/PhD/CH /2014/00523	CY	Swapnadip Roy	Development and Photophysical Study of Fluorescein Based Fluorescent Sensors and their Different Applications	Dr. S. S. Panja	03.08.2022
16	NITD/PhD/CS/ 2017/00876	CS	Krishnandu Hazra	Optimal Resource Planning for Situational Information Extraction During Post-Disaster Scenarios	Dr. S. Nandi Dr. S. Saha	08.08.2022
17	NITD/PhD/PH /2018/01026	PH	Kankana Seal	Investigation on water pollution scenario of Damodar river basin and treatment of organic contaminants in wastewater by the heterogeneous photocatalyst	Dr. S. Basu Dr. M. K. Mandal	12.08.2022

The award of the PhD degree to the above mentioned scholars are noted on the dates as mentioned against the respective scholar, to be reported to the Senate for recommendation.

Item # 4 To consider the appeal for an extension of period of registration of the following scholars

- Sushma (Roll No. 14/IT/1104, Reg. No. NITD/PhD/IT/2015/00648 dt. 16.09.2015)- extension for **2 (two) Yrs.** from 16.09.2020 (1st).
- Debi Prasad Das (Roll No. 13/CE/1503, Reg. No. NITD/PhD/CE/2016/00700 dt. 08.01.2016)- extension for 06 (six) months from 08.07.2022 (3rd).
- Anandaprova Majumder (Roll No. 13/CA/1503, Reg. No. NITD/PhD/CA/2016/00771 dt. 11.07.2016)- extension for 1 yr. from 11.07.2022 (2nd)
- Bishwarup Ghosh (Roll No. 14/MATH/1504, Reg. No. NITD/PhD/MATH/2016/00815 dt. 29.09.2016)-extension for 1 yr. from 29.09.2021 (1st)
- Sudeshna Devnath (Roll No. 16MA1102, Reg. No. NITD/PhD/MA/2017/00951 dt. 09.10.2017)- extension for 6 months from 09.10.2022 (1st)
- Sameep Gehlot (Roll No. 15/BT/1102, Reg. No. NITD/PhD/BT/2017/00962 dt. 11.10.2017)- extension for 1 yr. from 11.10.2022 (1st).
- Vivekananda Mukherjee (Roll No. 15/PH/1506, Reg. No. NITD/PhD/PH/2017/00920 dt. 19.07.2017)- extension for 1 yr. from 19.07.2022 (1st).
- Anshuman Mondal (Roll No. 16/CH/1507, Reg. No. NITD/PhD/CH/2018/01003 dt. 10.01.2018)- extension for 1 yr. from 10.01.2023 (1st).

RK

- Sudipta Deb (Roll No. 16/ME/1302, Reg. No. NITD/PhD/ME/2017/00865 dt. 07.02.2017)- extension for 1 yr. from 07.08.2022 (2nd).
- Sumit Ranjan Dasgupta (Roll No. 15/HS/1506, Reg. No. NITD/PhD/HS/2017/00937 dt. 25.09.2017)- extension for 1 yr. from 25.09.2022 (1st).
- Srinibas Rana (Roll No. 15/CSE/1509, Reg. No. NITD/PhD/CS/2017/00940 dt. 26.09.2017)- extension for 1 yr. from 26.09.2022 (1st).
- ~~Jayanta Pal (Roll No. 15/EC/1506, Reg. No. NITD/PhD/EC/2017/00971 dt. 18.10.2017)- extension for 1 yr. from 18.10.2022 (1st).~~
- ~~Partha Sarkar (Roll No. 15/EC/1507, Reg. No. NITD/PhD/EC/2017/00918 dt. **30.05.2017**)- extension for 1 yr. from **30.05.2022** (1st).~~
- ~~Soumen Ghosh (Roll No. 15/EC/1505, Reg. No. NITD/PhD/EC/2017/00970 dt. 18.10.2017)- extension for 1 yr. from 18.10.2022 (1st).~~
- Prakash Kumar (Roll No. 12/BT/1502, Reg. No. NITD/PhD/BT/2015/00642 dt. **09.09.2015**)- extension for 1 yr. from 09.09.2022 (3rd).
- Amit Mukhopadhyay (Roll No. 14/IT/1505, Reg. No. NITD/PhD/IT/2017/00854 dt. 30.01.2017)- extension for 1 yr. from 30.07.2022 (2nd).
- Nandan Banerji (Roll No. 15/IT/1103, Reg. No. NITD/PhD/IT/2016/00799 dt. 26.09.2016) – extension for 1 yr. from 26.09.2022 (2nd).
- Shetha Daniel (Roll No. 14/ME/1505, Reg. No. NITD/PhD/ME/2016/00813 dt. 28.09.2016)- extension for 1 yr. from 28.09.2022 (2nd).
- Dipak Kumar (Roll No. 16/CS/1101 Reg. No. NITD/PhD/CS/2017/00983 dt. 08.11.2017)- extension for 1 yr. from 8.11.2022 (1st).
- Pratyush Prasanna Das (Roll No. 16/EE/1503 Reg. No. NITD/PhD/EE/2017/00961 dt. 11.10.2017)-extension for 1 yr. from 11.10.2022 (1st)

The matter is recommended for approval as the formalities in this regard are fulfilled.
The matter related to Sushma (Roll No. 14/IT/1104, Reg. No. NITD/PhD/IT/2015/00648 dt. 16.09.2015) is referred to the Senate for discussion.
Further it is recommended for approval by the Senate for relaxation of one year extension for period of registration also for academic year 2022-2023 on specific recommendation of the respective DSC due to COVID19 situation.

Item # 5 **To consider the appeal for discontinuation from PhD Program**

- **Subhajit Dutta (Roll No. 20BT1110)**
- **Ragini Sengupta (Roll No. 21CY1101)**

The above matter has been discussed and as recommended by DSC of the students it may be forwarded to the Chairman, Senate for his approval.
The matter of release of regular Institute fellows will be guided by the regulations of the programme while the release of other regular fellows will be guided by the regulations of the respective funding agencies.

Item # 6 **To consider the matter regarding the approval for extension of period for delivering preregistration seminar:**

- **Rashid Imran Ahmad Khan (Roll No. 18CH1501, Date of Admission 26.07.2018)**
- **Anu Samanta (Roll No. 18EC1505, Date of Admission 27.07.2018)- permission to deliver PhD registration seminar within Jan, 2022 was approved earlier in RAC dt. 14.12.2021.**
- **Sumana Roy (Roll No. 19CH1501, Date of Admission 26.07.2019)-extension of date of pre-registration seminar upto December 2022.**
- **Sunil Kumar Choudhary (Roll No. 19EE1503, Date of Admission 26.07.2019)- extension of date of pre-registration seminar upto September 2022.**
- **Niti Rani (Roll No. 19EE1502, Date of Admission 26.07.2019)- extension of date of pre-registration seminar up to 31.12.2022**

The matter is recommended for approval.

The matter related to Rashid Imran Ahmad Khan (Roll No. 18CH1501, Date of Admission 26.07.2018) and Anu Samanta (Roll No. 18EC1505, Date of Admission 27.07.2018) are referred to the Senate for discussion.

Item # 7 **To consider the matter regarding the approval for Campus release of –**

- **Sanjit Bhowmick (Roll No. 17MA1108, Reg. No. 19RMA045, Thesis submitted on: 26.05.2022) Joined Post-Doctoral position in IIT Delhi on 28.06.2022.**
- **Sunil Kumar Patel (Roll No. 17CS1104, Reg. No. NITD/PhD/CS/2018/01036) Joined in School of Computing &Information Technology at Manipal University, Jaipur as an Assistant Professor.**
- **Anirban Hazra (Roll No. 21MM1101) Joined EXIDE R&D, Kolkata from 01.07.2022 as Technology Intern- R&D.**
- **Arghyadeep Bhattacharjee (Roll No. 20BT1111) Joined as Asst. Prof. in the Dept. of Microbiology, Kingston College of Science from 08.08.2022**

The matter is approved subject to submission of the NOC from the employer.
The scholarship will be stopped from the date of intimation regarding employment.

Item # 8 **To consider the matter regarding the approval of reconstitution of DSC:**

- **Teressa Longjam (Roll No. 16/CS/1501)- inclusion of Dr. Samarjit Kar (MA) in place of Dr. Sujit Kr. Mandal (EC).**
- **Rajrup Saha (Roll No. 18EC1106)- inclusion of co-supervisor Dr. Avishek Das, Asst. Prof., Dept. of ECE, Haldia Institute of Technology.**
- **Sumana Roy (Roll No. 19CH1501)-change of supervisor Dr. Sandip Kumar Lahiri (CH) in place of Dr. Swapan Paruya (CH).**
- **Kumar Roshan Bedia (Roll No. 21CH1104)- appeal of Dr. J. Sikder (CH) to withdraw of role as Co-supervisor.**
- **Sumit Ranjan Dasgupta (Roll No. 15/HS/1506)- inclusion of supervisor Dr. D. Chakraborty (HS).**
- **Shibaji Bose (Roll No. 21HS1501)- Inclusion; Dr. A. Modak (HS) as supervisor, as Dr. P. P. Sengupta (HS), retired from service on 31.08.2022 andwill act as co-supervisor.**
- **Dipak Kumar (Roll No. 16/CS/1101)- change of non-departmental faculty member of the Institute having PhD degreeDr. Rajib Kar (EC) in place of Dr. Sujit Kumar Mandal (EC).**
- **Amrita Mukherjee (Roll No. 20EC1102)- change in affiliation of Dr. Pratik Chakraborty (Co-supervisor) from DST-INSPIRE faculty at NIT Durgapur to Asst. Professor in the Department of ECE at IIIT Kalyani**

The matter is recommended for approval.

Item # 9 **To consider the matter regarding submission of synopsis and pre-registration seminar of Parbati Golui (Roll No. 18CH1502, Supervisor: Dr. S. Dutta).**

The matter is discussed and reffered back to the Department.

Item # 10 **To consider the appeal for Inclusion of NPTEL Certificate Score in Result of Ph.D Coursework Even Sem. 2021-2022 of Sandip Chakrabarty (Roll No. 20CS1503).**

The matter is recommended for approval.

Item # 11 **To consider the matter regarding the communication from the NITs division of MoE dated 28.06.2022 regarding visit of students in batches to Atal Tunnel Rohtang to understand the best practices in Engineering, Design, Planning, Construction and Project Management.**

The matter is recommended for approval in line with the resolutions adopted by the UGAC and PGAC in this regard. RK

Item # 12 **To consider the matter regarding an application from Mr. Sandipan Dhar (Roll No. 19CS1101, Reg. No. 21RCS057) on his requirement of PhD course work CGPA.**

The matter may be considered on case to case basis. However, the formula for calculation of CGPA is to be prepared and to be placed in the next meeting of the RAC.

Item # 13 **To consider the matter regarding allocation of institute scholars in each of the centres from academic year 2022-2023.**

The matter is discussed and referred to the Senate for further discussions.

Item # 14 **To consider an appeal from the department of Mathematics for late PhD Admission (Odd Semester 2022-2023) in September 2022 for a candidate of category B.**

The matter regarding completion of the process of the admission on 31.08.2022 in odd semester 2022 – 2023 is noted and the matter related to the appeal is referred to the Senate.

Item # 15 **To consider the matter regarding change of PhD programme category from 'Category C' to 'Category B' of Nandita Ghosh, Roll No. 20BT1113.**

The matter is recommended for approval.

Item # 16 **To consider the matter regarding request for submission of PhD thesis after 10 months of delivery of pre-synopsis submission seminar of Sabyasachi Pramanik (Roll No. 13/CHE/1501, Reg. No. NITD/PhD/ChE/2015/00591).**

The matter is discussed and Sabyasachi Pramanik (Roll No. 13/CHE/1501, Reg. No. NITD/PhD/ChE/2015/00591) may be allowed to appear for a pre-synopsis submission seminar on fulfilment of the formalities for the same and recommended for approval of one year extension of registration period from 06.08.2022.

Item # 17 **To consider the appeal of Geeta Verma (Roll No. 21ME1104) and Avishek Mukherjee (Roll No. 21ME1107) regarding extra 1 credit to acquire as per amended PhD Regulations (June, 2022).**

The matter is discussed and the provisions of the resolutions of the Senate vide item no. 62.8 of the meeting held on 08.11.2021 is to be followed.

Item # 18 **To consider the request of Dipanita Deb (Roll No. 16/MS/1304) for delivering pre-submission seminar by online mode.**

The matter is discussed and recommended for approval due to medical reason / special case and this case can not be shown as precedence .

Item # 19 **To consider the last date of defence for award of PhD degree in 18th Convocation to be held on 22/10/2022.**

The matter is discussed and resolved that the last date of defence for the award of PhD degree in the 18th Convocation will be 30/09/2022 on submission of all necessary documents and completion of formalities by 30/09/2022.

The meeting ended with vote of thanks to the Chairman.

Dean (Academic Research)
Date: 07.09.2022.

ANNEXURE 67.6

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

MAHATMA GANDHI AVENUE, DURGAPUR – 713209 (WEST BENGAL)

NOTE SHEET

Date: 12/09/22

In reference to the action taken report of item no. 66.2 (66th Senate); for consideration of equivalence of patent filing with one publication in an SCI/ SSCI/ AHCI/ Non-paid Scopus/ Web of Science journal, the deliberation of the senate constituted committee is given below.

The point no 7.5 (i) of PhD Regulations - 2021 can be amended in the following manner;
7.5. (i) The scholar must have at least two papers published / accepted for publication based on his/her doctoral research in a SCI/ SSCI/ AHCI/ Non-paid Scopus/ Web of Science journal and preferably two paper presentations in conferences/ seminars before the submission of the dissertation/thesis for adjudication, and produce evidence for the same in the form of presentation certificates and/or reprints.

OR

The scholar must have at least one paper published / accepted for publication based on his/her doctoral research in a SCI/ SSCI/ AHCI/ Non-paid Scopus/ Web of Science journal and at least one patent publication along with preferably two paper presentations in conferences/ seminars before the submission of the dissertation/thesis for adjudication, and produce evidence for the same in the form of presentation certificates and/or reprints.

Chiranjib Koley 13/09/2022

Convener,
Prof. Chiranjib Koley

Pathik Kumbhakar 13/09/2022

Chairman
Prof. Pathik Kumbhakar

REGISTRAR, NIT Durgapur

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
MAHATMA GANDHI AVENUE, DURGAPUR – 713209 (WEST BENGAL)

Minutes of the senate constituted committee meeting on Patent in Ph.D. Regulation held on 05.08.2022

Members present in the meeting

Prof. Chiranjib Koley (EE), — Chiranjib Koley

Prof. Pathik Kumbhakar, Dean (AR), PKumbhakar 05/08/2022

Prof. Tandra Pal (CSE), Tandra Pal 05/08/2022

Prof. Sudip Chattopadhyay (BT), Sudip Chattopadhyay 05/08/22.

Prof. Parimal Pal (CHE) Parimal Pal 5/8/22

The meeting was held in the meeting room of the Electrical Engineering department on 5th August 2022 at 5.30 PM, and the following points were discussed:

Agenda 1: Consideration of equivalence of patent filing with one publication in an SCI/ SSCI/ AHCI/ Non-paid Scopus/ Web of Science journal.

One paper published in SCI/SSCI/AHCI/Non-paid Scopus/Web of Science journal &
one patent ~~[illegible]~~ publication. ~~in patent journal~~
OR
As per existing norms given in PhD Regulations (Clause 7.5).

Agenda 2: Report that is to be submitted to the Chairman of the Senate.

The meeting ended with a vote of thanks to all the members.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

INDIA

ANNEXURE 67.7

18TH CONVOCATION

TENTATIVE DATE OF CONVOCATION : Second Week of September 2022

LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
1	18BT8001	18U10069	Bachelor of Technology in	Biotechnology	on	Sayanta Ghosh			
2	18BT8002	18U10089	Bachelor of Technology in	Biotechnology	on	Rishavdeb Gayen			
3	18BT8003	18U10116	Bachelor of Technology in	Biotechnology	on	Surjya Roy			
4	18BT8004	18U10119	Bachelor of Technology in	Biotechnology	on	Amlan Mandal			
5	18BT8005	18U10135	Bachelor of Technology in	Biotechnology	on	Sayani Saha			
6	18BT8007	18U10149	Bachelor of Technology in	Biotechnology	on	Arijit Roy			
7	18BT8008	18U10166	Bachelor of Technology in	Biotechnology	on	Bedashruti Majumdar			
8	18BT8009	18U10172	Bachelor of Technology in	Biotechnology	on	Ahana Sarkar			
9	18BT8010	18U10182	Bachelor of Technology in	Biotechnology	on	Subhra Ghosh			
10	18BT8011	18U10192	Bachelor of Technology in	Biotechnology	on	Saikat Paul			
11	18BT8012	18U10214	Bachelor of Technology in	Biotechnology	on	Tushar Shukla			
12	18BT8013	18U10272	Bachelor of Technology in	Biotechnology	on	Priti Maji			
13	18BT8014	18U10298	Bachelor of Technology in	Biotechnology	on	Pragnam Shelsi			
14	18BT8015	18U10314	Bachelor of Technology in	Biotechnology	on	Jintu Moni Nath			
15	18BT8016	18U10381	Bachelor of Technology in	Biotechnology	on	Abhishek Raj			
16	18BT8017	18U10401	Bachelor of Technology in	Biotechnology	on	Panchsheel			
17	18BT8018	18U10455	Bachelor of Technology in	Biotechnology	on	Sabavath Rajesh			
18	18BT8019	18U10457	Bachelor of Technology in	Biotechnology	on	Gondhi Sai Kumar			
19	18BT8021	18U10504	Bachelor of Technology in	Biotechnology	on	Srijini Pal			
20	18BT8024	18U10521	Bachelor of Technology in	Biotechnology	on	Arjya Singh Roy			
21	18BT8025	18U10523	Bachelor of Technology in	Biotechnology	on	Praneet Kumar Sahoo			
22	18BT8026	18U10530	Bachelor of Technology in	Biotechnology	on	Buti Singh			

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA
18TH CONVOCATION
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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
23	18BT8027	18U10536	Bachelor of Technology in	Biotechnology	on	Prarthita Rakshit			
24	18BT8028	18U10537	Bachelor of Technology in	Biotechnology	on	Akash Chowbey			
25	18BT8029	18U10543	Bachelor of Technology in	Biotechnology	on	Saurabh Kumar			
26	18BT8030	18U10544	Bachelor of Technology in	Biotechnology	on	Salari Charan Balajee			
27	18BT8031	18U10549	Bachelor of Technology in	Biotechnology	on	Chavan Swathi			
28	18BT8033	18U10604	Bachelor of Technology in	Biotechnology	on	Anamitra Singha			
29	18BT8034	18U10609	Bachelor of Technology in	Biotechnology	on	Abhrajit Saha			
30	18BT8035	18U10613	Bachelor of Technology in	Biotechnology	on	Sayantan Maity			
31	18BT8036	18U10614	Bachelor of Technology in	Biotechnology	on	Rounak Sarkar			
32	18BT8038	18U10627	Bachelor of Technology in	Biotechnology	on	Garigipati Shivapriya			
33	18BT8040	18U10632	Bachelor of Technology in	Biotechnology	on	Paloju Hari Prasad			
34	18BT8041	18U10639	Bachelor of Technology in	Biotechnology	on	Pratiksha Patel			
35	18BT8042	18U10640	Bachelor of Technology in	Biotechnology	on	Anish Maitra			
36	18BT8043	18U10641	Bachelor of Technology in	Biotechnology	on	Ashish Jaiswal			
37	18BT8044	18U10653	Bachelor of Technology in	Biotechnology	on	Harshit Agrawal			
38	18BT8046	18U10663	Bachelor of Technology in	Biotechnology	on	Sneha Roy			
39	18BT8047	18U10665	Bachelor of Technology in	Biotechnology	on	Mahesh Kumar			
40	18BT8049	18U10672	Bachelor of Technology in	Biotechnology	on	Sujata Mandal			
41	18BT8050	18U10682	Bachelor of Technology in	Biotechnology	on	Priyanka Kumari			
42	18BT8051	18U10683	Bachelor of Technology in	Biotechnology	on	Valasala Lakshmanrao			
43	18BT8052	18U10687	Bachelor of Technology in	Biotechnology	on	Akula Maruthi Ayyannarao			
44	18BT8053	18U10688	Bachelor of Technology in	Biotechnology	on	Dheerendra Goyal			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
45	18BT8054	18U10693	Bachelor of Technology in	Biotechnology	on	Pratyush Ghosh			
46	18BT8055	18U10695	Bachelor of Technology in	Biotechnology	on	Monu Kumar			
47	18BT8056	18U10698	Bachelor of Technology in	Biotechnology	on	Hari Om			
48	18BT8057	18U10706	Bachelor of Technology in	Biotechnology	on	Bandeppa			
49	18BT8058	18U10710	Bachelor of Technology in	Biotechnology	on	Prakriti Singh			
50	18BT8059	18U10732	Bachelor of Technology in	Biotechnology	on	Parmatma Kumar			
51	18BT8060	18U10744	Bachelor of Technology in	Biotechnology	on	Dwarapudi Rajasekhar			
52	18BT8061	18U10746	Bachelor of Technology in	Biotechnology	on	Kritika Sahoo			
53	18BT8062	18U10756	Bachelor of Technology in	Biotechnology	on	C.V.Manvi			
54	18BT8063	18U10760	Bachelor of Technology in	Biotechnology	on	Yogesh Kumar Dogra			
55	18BT8064	18U10762	Bachelor of Technology in	Biotechnology	on	B Aditi			
56	18BT8065	18U10768	Bachelor of Technology in	Biotechnology	on	Manish Moond			
57	17CE8008	17U10130	Bachelor of Technology in	Civil Engineering	on	Kadai Krishna Majhi			
58	17CE8026	17U10373	Bachelor of Technology in	Civil Engineering	on	Adarsh Kumar Harit			
59	18CE8001	18U10013	Bachelor of Technology in	Civil Engineering	on	Apurba Sardar			
60	18CE8002	18U10058	Bachelor of Technology in	Civil Engineering	on	Tanmoy Sahoo			
61	18CE8003	18U10059	Bachelor of Technology in	Civil Engineering	on	Dipan Kumar Das			
62	18CE8004	18U10066	Bachelor of Technology in	Civil Engineering	on	Sougata Mandi			
63	18CE8005	18U10073	Bachelor of Technology in	Civil Engineering	on	Thyelshangran Moriah Khaling			
64	18CE8006	18U10102	Bachelor of Technology in	Civil Engineering	on	Suman Kumari			
65	18CE8007	18U10104	Bachelor of Technology in	Civil Engineering	on	Bikram Dey			
66	18CE8008	18U10110	Bachelor of Technology in	Civil Engineering	on	Krishanu Sikdar			

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
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18TH CONVOCATION

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LIST OF B.TECH /DUAL DEGREE / INTEGRATED M.Sc DEGREE RECIPIENTS

Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
67	18CE8009	18U10124	Bachelor of Technology in	Civil Engineering	on	Disha De			
68	18CE8010	18U10129	Bachelor of Technology in	Civil Engineering	on	Debpratim Sinha			
69	18CE8011	18U10150	Bachelor of Technology in	Civil Engineering	on	Md Danish Khan			
70	18CE8012	18U10178	Bachelor of Technology in	Civil Engineering	on	Saurav Kumar			
71	18CE8013	18U10185	Bachelor of Technology in	Civil Engineering	on	Amlan Kar			
72	18CE8014	18U10191	Bachelor of Technology in	Civil Engineering	on	Raghav Acharya			
73	18CE8016	18U10195	Bachelor of Technology in	Civil Engineering	on	Manoj Layek			
74	18CE8017	18U10202	Bachelor of Technology in	Civil Engineering	on	Sourjyendra Krishna Deb			
75	18CE8018	18U10208	Bachelor of Technology in	Civil Engineering	on	Aatif Hanif			
76	18CE8020	18U10291	Bachelor of Technology in	Civil Engineering	on	Kolipakula Uday Kiran			
77	18CE8021	18U10295	Bachelor of Technology in	Civil Engineering	on	Bindas R Jorwal			
78	18CE8022	18U10297	Bachelor of Technology in	Civil Engineering	on	Monavarthi Sri Sai Aadarsh			
79	18CE8023	18U10302	Bachelor of Technology in	Civil Engineering	on	Bolla Sai Gopal			
80	18CE8024	18U10316	Bachelor of Technology in	Civil Engineering	on	Sonu Kumar			
81	18CE8025	18U10320	Bachelor of Technology in	Civil Engineering	on	Suman Kumar Patra			
82	18CE8026	18U10322	Bachelor of Technology in	Civil Engineering	on	Shraddha Majumder			
83	18CE8027	18U10327	Bachelor of Technology in	Civil Engineering	on	Abhinav Verma			
84	18CE8028	18U10333	Bachelor of Technology in	Civil Engineering	on	Kishan Kumar			
85	18CE8029	18U10335	Bachelor of Technology in	Civil Engineering	on	Saurabh Kumar Singh			
86	18CE8030	18U10338	Bachelor of Technology in	Civil Engineering	on	Masarapu Naga Karishma Mounika			
87	18CE8031	18U10391	Bachelor of Technology in	Civil Engineering	on	Kalluri Raja Shekar Reddy			
88	18CE8032	18U10402	Bachelor of Technology in	Civil Engineering	on	Debanjan Mahalanabis			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
89	18CE8033	18U10424	Bachelor of Technology in	Civil Engineering	on	Atul Kumar			
90	18CE8034	18U10427	Bachelor of Technology in	Civil Engineering	on	Shalini Satapathy			
91	18CE8035	18U10434	Bachelor of Technology in	Civil Engineering	on	Duppada Sai Kowshik			
92	18CE8036	18U10438	Bachelor of Technology in	Civil Engineering	on	Ashwini Gupta			
93	18CE8037	18U10497	Bachelor of Technology in	Civil Engineering	on	Naragana Jaya Chandra Gowd			
94	18CE8038	18U10512	Bachelor of Technology in	Civil Engineering	on	Sujoy Bhattacharya			
95	18CE8039	18U10519	Bachelor of Technology in	Civil Engineering	on	Saikat Ghosh			
96	18CE8040	18U10527	Bachelor of Technology in	Civil Engineering	on	Anitra Koner			
97	18CE8041	18U10531	Bachelor of Technology in	Civil Engineering	on	Subhajoy Mahanta			
98	18CE8042	18U10538	Bachelor of Technology in	Civil Engineering	on	Lankothu Damaraka Akhil			
99	18CE8044	18U10575	Bachelor of Technology in	Civil Engineering	on	Ankit Chaudhary			
100	18CE8045	18U10576	Bachelor of Technology in	Civil Engineering	on	Nipun Kumar			
101	18CE8046	18U10579	Bachelor of Technology in	Civil Engineering	on	Aurojeet Jena			
102	18CE8047	18U10582	Bachelor of Technology in	Civil Engineering	on	Sumana Nath			
103	18CE8048	18U10592	Bachelor of Technology in	Civil Engineering	on	Avinash Singh			
104	18CE8049	18U10597	Bachelor of Technology in	Civil Engineering	on	Gourab Agarwal			
105	18CE8050	18U10601	Bachelor of Technology in	Civil Engineering	on	Arka Mandal			
106	18CE8051	18U10606	Bachelor of Technology in	Civil Engineering	on	Debojyoti Mandal			
107	18CE8052	18U10618	Bachelor of Technology in	Civil Engineering	on	Sayantan Bishnu			
108	18CE8053	18U10619	Bachelor of Technology in	Civil Engineering	on	Aradhya Rajor			
109	18CE8054	18U10626	Bachelor of Technology in	Civil Engineering	on	Kolla Sudhir Kumar			
110	18CE8055	18U10642	Bachelor of Technology in	Civil Engineering	on	Sudhanshu Saumya			

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111	18CE8056	18U10643	Bachelor of Technology in	Civil Engineering	on	Shalini Roy			
112	18CE8058	18U10661	Bachelor of Technology in	Civil Engineering	on	Dhulipala Dheeraj			
113	18CE8059	18U10708	Bachelor of Technology in	Civil Engineering	on	Ankita Raj			
114	18CE8060	18U10713	Bachelor of Technology in	Civil Engineering	on	Devisetty Sabari Deekshith			
115	18CE8061	18U10718	Bachelor of Technology in	Civil Engineering	on	Pavuluri Ruthwik Venkata Siva Sai			
116	18CE8062	18U10740	Bachelor of Technology in	Civil Engineering	on	Gedala Naidu			
117	18CE8063	18U10761	Bachelor of Technology in	Civil Engineering	on	Jijith Sudev			
118	18CE8064	18U10765	Bachelor of Technology in	Civil Engineering	on	S Meynesh			
119	18CH8001	18U10022	Bachelor of Technology in	Chemical Engineering	on	Souvik Ghosh			
120	18CH8003	18U10046	Bachelor of Technology in	Chemical Engineering	on	Tiyasha Ghosh			
121	18CH8004	18U10062	Bachelor of Technology in	Chemical Engineering	on	Soham Roy Chowdhury			
122	18CH8005	18U10063	Bachelor of Technology in	Chemical Engineering	on	Rhythm Aich			
123	18CH8006	18U10083	Bachelor of Technology in	Chemical Engineering	on	Arnab Mandal			
124	18CH8007	18U10099	Bachelor of Technology in	Chemical Engineering	on	Souma Das			
125	18CH8008	18U10100	Bachelor of Technology in	Chemical Engineering	on	Rishav Kumar Rathore			
126	18CH8009	18U10113	Bachelor of Technology in	Chemical Engineering	on	Kusuma Vasanth Kumar			
127	18CH8010	18U10134	Bachelor of Technology in	Chemical Engineering	on	Pritam Mandal			
128	18CH8011	18U10139	Bachelor of Technology in	Chemical Engineering	on	Joy Mallick			
129	18CH8012	18U10146	Bachelor of Technology in	Chemical Engineering	on	Kritika Raman			
130	18CH8013	18U10151	Bachelor of Technology in	Chemical Engineering	on	Annasha Dey			
131	18CH8014	18U10197	Bachelor of Technology in	Chemical Engineering	on	Samannoy Mukherjee			
132	18CH8015	18U10223	Bachelor of Technology in	Chemical Engineering	on	Ankita Bhattacharya			

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133	18CH8017	18U10242	Bachelor of Technology in	Chemical Engineering	on	Satendra Singh			
134	18CH8018	18U10261	Bachelor of Technology in	Chemical Engineering	on	Harshit Shrinet			
135	18CH8019	18U10270	Bachelor of Technology in	Chemical Engineering	on	Saumyajeet Mukherjee			
136	18CH8020	18U10274	Bachelor of Technology in	Chemical Engineering	on	Priyabrata Pani			
137	18CH8021	18U10280	Bachelor of Technology in	Chemical Engineering	on	Sk Asfak Uddin			
138	18CH8022	18U10283	Bachelor of Technology in	Chemical Engineering	on	Aranyo Banerjee			
139	18CH8023	18U10289	Bachelor of Technology in	Chemical Engineering	on	Kareena Deka Baruah			
140	18CH8024	18U10294	Bachelor of Technology in	Chemical Engineering	on	Ashis Bera			
141	18CH8025	18U10300	Bachelor of Technology in	Chemical Engineering	on	Somayajula Rittika			
142	18CH8026	18U10307	Bachelor of Technology in	Chemical Engineering	on	Abhishek Dey			
143	18CH8027	18U10317	Bachelor of Technology in	Chemical Engineering	on	Ayush Nath			
144	18CH8028	18U10323	Bachelor of Technology in	Chemical Engineering	on	Arnav Hemant Sakhare			
145	18CH8029	18U10361	Bachelor of Technology in	Chemical Engineering	on	Vivek Garg			
146	18CH8030	18U10364	Bachelor of Technology in	Chemical Engineering	on	Chitikala Gireswar			
147	18CH8031	18U10376	Bachelor of Technology in	Chemical Engineering	on	Ashutosh Mishra			
148	18CH8032	18U10400	Bachelor of Technology in	Chemical Engineering	on	Moirangthem Sarda Devi			
149	18CH8033	18U10404	Bachelor of Technology in	Chemical Engineering	on	Addepalli Sai Sanjay Varma			
150	18CH8035	18U10409	Bachelor of Technology in	Chemical Engineering	on	Piyanjana Ghosh			
151	18CH8036	18U10441	Bachelor of Technology in	Chemical Engineering	on	Md Yasin Ansari			
152	18CH8037	18U10446	Bachelor of Technology in	Chemical Engineering	on	Puli Prasanna Paul			
153	18CH8038	18U10447	Bachelor of Technology in	Chemical Engineering	on	Saikat Das			
154	18CH8039	18U10466	Bachelor of Technology in	Chemical Engineering	on	Muta Giridhar Naidu			

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155	18CH8041	18U10505	Bachelor of Technology in	Chemical Engineering	on	Suchismita Khan			
156	18CH8042	18U10509	Bachelor of Technology in	Chemical Engineering	on	Gourab Mondal			
157	18CH8043	18U10517	Bachelor of Technology in	Chemical Engineering	on	Laxmi Saro Hembrom			
158	18CH8044	18U10541	Bachelor of Technology in	Chemical Engineering	on	Souvik Daripa			
159	18CH8045	18U10554	Bachelor of Technology in	Chemical Engineering	on	Samriddha Saha			
160	18CH8046	18U10558	Bachelor of Technology in	Chemical Engineering	on	Vivek Sunil Kumar Jha			
161	18CH8047	18U10559	Bachelor of Technology in	Chemical Engineering	on	Varun Kumar Singh			
162	18CH8048	18U10562	Bachelor of Technology in	Chemical Engineering	on	P M R Vedhanand			
163	18CH8049	18U10571	Bachelor of Technology in	Chemical Engineering	on	Tamoghna Bhattacharjee			
164	18CH8051	18U10589	Bachelor of Technology in	Chemical Engineering	on	Amar Kumar Pandey			
165	18CH8052	18U10616	Bachelor of Technology in	Chemical Engineering	on	Sakshi Singh			
166	18CH8053	18U10635	Bachelor of Technology in	Chemical Engineering	on	Piyush Kumar Dwivedi			
167	18CH8054	18U10637	Bachelor of Technology in	Chemical Engineering	on	Sneha Rani Dey			
168	18CH8055	18U10664	Bachelor of Technology in	Chemical Engineering	on	Anuj Patel			
169	18CH8056	18U10674	Bachelor of Technology in	Chemical Engineering	on	Proshanta Singha			
170	18CH8057	18U10681	Bachelor of Technology in	Chemical Engineering	on	Kiranmaya Puhan			
171	18CH8058	18U10686	Bachelor of Technology in	Chemical Engineering	on	Mohd Sakir			
172	18CH8060	18U10723	Bachelor of Technology in	Chemical Engineering	on	Abhinandan Kumar			
173	18CH8061	18U10733	Bachelor of Technology in	Chemical Engineering	on	Deerasa			
174	18CH8062	18U10734	Bachelor of Technology in	Chemical Engineering	on	Zeeshan Akhtar			
175	18CH8063	18U10735	Bachelor of Technology in	Chemical Engineering	on	Badavath Suman			
176	17CS8003	17U10004	Bachelor of Technology in	Computer Science and Engineering	on	Swarnavo Chakrabarti			

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177	18CS8001	18U10001	Bachelor of Technology in	Computer Science and Engineering	on	Spandan Pal			
178	18CS8002	18U10002	Bachelor of Technology in	Computer Science and Engineering	on	Binit Kumar Singh			
179	18CS8003	18U10004	Bachelor of Technology in	Computer Science and Engineering	on	Sayan Pal			
180	18CS8004	18U10006	Bachelor of Technology in	Computer Science and Engineering	on	Reeya Raj Singh			
181	18CS8005	18U10007	Bachelor of Technology in	Computer Science and Engineering	on	Shriya Das			
182	18CS8007	18U10016	Bachelor of Technology in	Computer Science and Engineering	on	Amish Bharti			
183	18CS8008	18U10018	Bachelor of Technology in	Computer Science and Engineering	on	Saurav Das			
184	18CS8009	18U10019	Bachelor of Technology in	Computer Science and Engineering	on	Shubhank Chandak			
185	18CS8010	18U10020	Bachelor of Technology in	Computer Science and Engineering	on	Debaditya Dutta			
186	18CS8011	18U10021	Bachelor of Technology in	Computer Science and Engineering	on	Shaon Kumar Debnath			
187	18CS8012	18U10033	Bachelor of Technology in	Computer Science and Engineering	on	Shreoshree Adhikari			
188	18CS8013	18U10038	Bachelor of Technology in	Computer Science and Engineering	on	Avinandan Pal			
189	18CS8014	18U10040	Bachelor of Technology in	Computer Science and Engineering	on	Rohit Lama			
190	18CS8015	18U10042	Bachelor of Technology in	Computer Science and Engineering	on	Subhayu Ghosh			
191	18CS8016	18U10048	Bachelor of Technology in	Computer Science and Engineering	on	Saswata Bagchi			
192	18CS8017	18U10051	Bachelor of Technology in	Computer Science and Engineering	on	Sumana Mukherjee			
193	18CS8018	18U10052	Bachelor of Technology in	Computer Science and Engineering	on	Hritesh Mourya			
194	18CS8019	18U10053	Bachelor of Technology in	Computer Science and Engineering	on	Romit Karmakar			
195	18CS8020	18U10054	Bachelor of Technology in	Computer Science and Engineering	on	Abhik Mahato			
196	18CS8021	18U10055	Bachelor of Technology in	Computer Science and Engineering	on	Riddhi Roy			
197	18CS8022	18U10056	Bachelor of Technology in	Computer Science and Engineering	on	Sarfaraz Ahmad			
198	18CS8023	18U10061	Bachelor of Technology in	Computer Science and Engineering	on	Manish Manojan			

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199	18CS8024	18U10067	Bachelor of Technology in	Computer Science and Engineering	on	Molla Saroyar Hossain			
200	18CS8025	18U10071	Bachelor of Technology in	Computer Science and Engineering	on	Anirban Nayek			
201	18CS8026	18U10072	Bachelor of Technology in	Computer Science and Engineering	on	Devam Kumar Anand			
202	18CS8027	18U10077	Bachelor of Technology in	Computer Science and Engineering	on	Surya Prakash			
203	18CS8028	18U10079	Bachelor of Technology in	Computer Science and Engineering	on	Prasun Kumar Bhuin			
204	18CS8029	18U10080	Bachelor of Technology in	Computer Science and Engineering	on	Aman Lama			
205	18CS8030	18U10082	Bachelor of Technology in	Computer Science and Engineering	on	Pritam Dutta			
206	18CS8031	18U10085	Bachelor of Technology in	Computer Science and Engineering	on	Karan Singh			
207	18CS8032	18U10086	Bachelor of Technology in	Computer Science and Engineering	on	Rohit Shukla			
208	18CS8033	18U10087	Bachelor of Technology in	Computer Science and Engineering	on	Himanshu Shekhar Jha			
209	18CS8035	18U10105	Bachelor of Technology in	Computer Science and Engineering	on	Rajnish Raj			
210	18CS8036	18U10115	Bachelor of Technology in	Computer Science and Engineering	on	Abhishek Kumar			
211	18CS8037	18U10117	Bachelor of Technology in	Computer Science and Engineering	on	Choppala Paul Bright			
212	18CS8039	18U10127	Bachelor of Technology in	Computer Science and Engineering	on	Sourav Karmakar			
213	18CS8041	18U10144	Bachelor of Technology in	Computer Science and Engineering	on	Pratim Mandal			
214	18CS8042	18U10148	Bachelor of Technology in	Computer Science and Engineering	on	Aniket Ray			
215	18CS8044	18U10153	Bachelor of Technology in	Computer Science and Engineering	on	Proma Roy			
216	18CS8045	18U10157	Bachelor of Technology in	Computer Science and Engineering	on	Sailesh Kumar			
217	18CS8046	18U10159	Bachelor of Technology in	Computer Science and Engineering	on	Swarup Roy			
218	18CS8047	18U10161	Bachelor of Technology in	Computer Science and Engineering	on	Akarshan Chatterjee			
219	18CS8048	18U10162	Bachelor of Technology in	Computer Science and Engineering	on	Vaibhav Misra			
220	18CS8049	18U10164	Bachelor of Technology in	Computer Science and Engineering	on	Alka Oraon			

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221	18CS8050	18U10167	Bachelor of Technology in	Computer Science and Engineering	on	Avirup Mazumder			
222	18CS8051	18U10170	Bachelor of Technology in	Computer Science and Engineering	on	Anupam Minj			
223	18CS8052	18U10174	Bachelor of Technology in	Computer Science and Engineering	on	Onkar Sardar			
224	18CS8053	18U10179	Bachelor of Technology in	Computer Science and Engineering	on	Nitesh Kumar Prasad			
225	18CS8054	18U10187	Bachelor of Technology in	Computer Science and Engineering	on	Kotana Sai			
226	18CS8055	18U10190	Bachelor of Technology in	Computer Science and Engineering	on	Joyeeta Mandal			
227	18CS8056	18U10196	Bachelor of Technology in	Computer Science and Engineering	on	Nisha Bharti			
228	18CS8057	18U10201	Bachelor of Technology in	Computer Science and Engineering	on	Jugnu			
229	18CS8058	18U10207	Bachelor of Technology in	Computer Science and Engineering	on	Madiki Mounika			
230	18CS8059	18U10211	Bachelor of Technology in	Computer Science and Engineering	on	Thota Sugandha Siddieswar			
231	18CS8060	18U10219	Bachelor of Technology in	Computer Science and Engineering	on	Rajendra Nath Murmu			
232	18CS8061	18U10222	Bachelor of Technology in	Computer Science and Engineering	on	Saharsh Ananta Jaiswal			
233	18CS8062	18U10226	Bachelor of Technology in	Computer Science and Engineering	on	Pudi Pavan Kumar			
234	18CS8063	18U10233	Bachelor of Technology in	Computer Science and Engineering	on	Ayesha Uzma			
235	18CS8064	18U10238	Bachelor of Technology in	Computer Science and Engineering	on	Rithik Sureka			
236	18CS8065	18U10243	Bachelor of Technology in	Computer Science and Engineering	on	Ravupalli Harsha Vardhan			
237	18CS8066	18U10247	Bachelor of Technology in	Computer Science and Engineering	on	Indrajeet Soreng			
238	18CS8067	18U10248	Bachelor of Technology in	Computer Science and Engineering	on	Nitesh Kumar			
239	18CS8068	18U10250	Bachelor of Technology in	Computer Science and Engineering	on	Chilukuri Sri Harsha			
240	18CS8069	18U10252	Bachelor of Technology in	Computer Science and Engineering	on	Md Afzal Nayeem			
241	18CS8070	18U10253	Bachelor of Technology in	Computer Science and Engineering	on	Md Umar			
242	18CS8071	18U10254	Bachelor of Technology in	Computer Science and Engineering	on	Simran Singh			

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243	18CS8072	18U10255	Bachelor of Technology in	Computer Science and Engineering	on	Ashwini Suryawanshi			
244	18CS8073	18U10262	Bachelor of Technology in	Computer Science and Engineering	on	Samrat Kundu			
245	18CS8074	18U10264	Bachelor of Technology in	Computer Science and Engineering	on	Penumuchu Sri Satwik			
246	18CS8075	18U10277	Bachelor of Technology in	Computer Science and Engineering	on	Varsha Tanti			
247	18CS8076	18U10279	Bachelor of Technology in	Computer Science and Engineering	on	Saptarshi Mondal			
248	18CS8077	18U10281	Bachelor of Technology in	Computer Science and Engineering	on	Priyesh Deep Kumar			
249	18CS8078	18U10286	Bachelor of Technology in	Computer Science and Engineering	on	Kala Yaduveera Chowdaiah			
250	18CS8079	18U10287	Bachelor of Technology in	Computer Science and Engineering	on	Kalivarapu Adithya			
251	18CS8080	18U10288	Bachelor of Technology in	Computer Science and Engineering	on	Debananda Das			
252	18CS8081	18U10305	Bachelor of Technology in	Computer Science and Engineering	on	Dolly Raj			
253	18CS8082	18U10318	Bachelor of Technology in	Computer Science and Engineering	on	Mohammed Yaseen			
254	18CS8084	18U10328	Bachelor of Technology in	Computer Science and Engineering	on	Raju Hoque			
255	18CS8085	18U10336	Bachelor of Technology in	Computer Science and Engineering	on	Martand Pratap Singh			
256	18CS8086	18U10340	Bachelor of Technology in	Computer Science and Engineering	on	Nokom Konyak			
257	18CS8087	18U10344	Bachelor of Technology in	Computer Science and Engineering	on	Vishwas Verma			
258	18CS8088	18U10345	Bachelor of Technology in	Computer Science and Engineering	on	Vasireddy Veeraveni Mahalakshmi			
259	18CS8089	18U10350	Bachelor of Technology in	Computer Science and Engineering	on	Risabh Udgata			
260	18CS8090	18U10352	Bachelor of Technology in	Computer Science and Engineering	on	Vemu Reesa Rejoice			
261	18CS8092	18U10359	Bachelor of Technology in	Computer Science and Engineering	on	Banoth Naresh			
262	18CS8093	18U10363	Bachelor of Technology in	Computer Science and Engineering	on	Konuganti Naveen Reddy			
263	18CS8094	18U10366	Bachelor of Technology in	Computer Science and Engineering	on	Seelam Penchala Prathush Goud			
264	18CS8096	18U10372	Bachelor of Technology in	Computer Science and Engineering	on	Prince			

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265	18CS8097	18U10373	Bachelor of Technology in	Computer Science and Engineering	on	Arya Verma			
266	18CS8098	18U10378	Bachelor of Technology in	Computer Science and Engineering	on	Prakhar Kumar			
267	18CS8099	18U10379	Bachelor of Technology in	Computer Science and Engineering	on	Suneha Maiti			
268	18CS8101	18U10383	Bachelor of Technology in	Computer Science and Engineering	on	Sampark Sharma			
269	18CS8102	18U10385	Bachelor of Technology in	Computer Science and Engineering	on	Duvvuri Veereshwara Satya Vineeth			
270	18CS8103	18U10386	Bachelor of Technology in	Computer Science and Engineering	on	Patel Rushil			
271	18CS8104	18U10388	Bachelor of Technology in	Computer Science and Engineering	on	Surapureddi Venkata Sai Harshith			
272	18CS8105	18U10389	Bachelor of Technology in	Computer Science and Engineering	on	Shankhasubhro Roy			
273	18CS8106	18U10390	Bachelor of Technology in	Computer Science and Engineering	on	Buchala Dheeraj Kumar			
274	18CS8107	18U10396	Bachelor of Technology in	Computer Science and Engineering	on	Alla Dharma Teja			
275	18CS8108	18U10397	Bachelor of Technology in	Computer Science and Engineering	on	Priyanshu Verma			
276	18CS8109	18U10399	Bachelor of Technology in	Computer Science and Engineering	on	Vydana Sai Aakash			
277	18CS8110	18U10416	Bachelor of Technology in	Computer Science and Engineering	on	Gangala Charmila Tanvi			
278	18CS8111	18U10429	Bachelor of Technology in	Computer Science and Engineering	on	Kalvakuntla Phani Santhosh			
279	18CS8112	18U10433	Bachelor of Technology in	Computer Science and Engineering	on	Madhila Devaraju			
280	18CS8113	18U10436	Bachelor of Technology in	Computer Science and Engineering	on	Machammagari Parthasai Reddy			
281	18CS8114	18U10442	Bachelor of Technology in	Computer Science and Engineering	on	Devam Kakoty			
282	18CS8115	18U10443	Bachelor of Technology in	Computer Science and Engineering	on	Devraj Kakoty			
283	18CS8116	18U10445	Bachelor of Technology in	Computer Science and Engineering	on	Shrimoyee Ghosh			
284	18CS8117	18U10448	Bachelor of Technology in	Computer Science and Engineering	on	Mohit Agarwal			
285	18CS8118	18U10452	Bachelor of Technology in	Computer Science and Engineering	on	Aryan Kodap			
286	18CS8119	18U10453	Bachelor of Technology in	Computer Science and Engineering	on	Mohammed Shahin Sharafudheen			

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287	18CS8120	18U10458	Bachelor of Technology in	Computer Science and Engineering	on	Hindol Kumar Das			
288	18CS8121	18U10459	Bachelor of Technology in	Computer Science and Engineering	on	Arjun Menon			
289	18CS8122	18U10463	Bachelor of Technology in	Computer Science and Engineering	on	Badnaini Lavanya			
290	18CS8123	18U10472	Bachelor of Technology in	Computer Science and Engineering	on	Kajal Meghani			
291	18CS8124	18U10473	Bachelor of Technology in	Computer Science and Engineering	on	Amit Bose			
292	18CS8125	18U10475	Bachelor of Technology in	Computer Science and Engineering	on	Srijeeta Das			
293	18CS8126	18U10476	Bachelor of Technology in	Computer Science and Engineering	on	Diganta Mitra			
294	18CS8127	18U10482	Bachelor of Technology in	Computer Science and Engineering	on	Soumik Samanta			
295	18CS8128	18U10483	Bachelor of Technology in	Computer Science and Engineering	on	Ayan Sarkar			
296	18CS8129	18U10484	Bachelor of Technology in	Computer Science and Engineering	on	Akash Manna			
297	18CS8130	18U10487	Bachelor of Technology in	Computer Science and Engineering	on	Aritro Saha			
298	18CS8131	18U10488	Bachelor of Technology in	Computer Science and Engineering	on	Shubham Kumar			
299	18CS8132	18U10489	Bachelor of Technology in	Computer Science and Engineering	on	Vikash Churiwala			
300	18CS8133	18U10491	Bachelor of Technology in	Computer Science and Engineering	on	Ganugula Suneetha			
301	18CS8134	18U10494	Bachelor of Technology in	Computer Science and Engineering	on	Yathansh A Jain			
302	18CS8135	18U10496	Bachelor of Technology in	Computer Science and Engineering	on	Subhodeep Santra			
303	18CS8136	18U10498	Bachelor of Technology in	Computer Science and Engineering	on	Chirag Agarwal			
304	18CS8137	18U10503	Bachelor of Technology in	Computer Science and Engineering	on	Ankit Jaiswal			
305	18CS8138	18U10514	Bachelor of Technology in	Computer Science and Engineering	on	Abhishek Gupta			
306	18CS8139	18U10515	Bachelor of Technology in	Computer Science and Engineering	on	Arunava Sarkar			
307	18CS8140	18U10522	Bachelor of Technology in	Computer Science and Engineering	on	Rajas Ajay Kulkarni			
308	18CS8141	18U10528	Bachelor of Technology in	Computer Science and Engineering	on	Soumyodeep Dey			

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309	18CS8142	18U10547	Bachelor of Technology in	Computer Science and Engineering	on	Jonnala Keerthi			
310	18CS8143	18U10548	Bachelor of Technology in	Computer Science and Engineering	on	Pedakota Venkatasai Priyatham			
311	18CS8144	18U10553	Bachelor of Technology in	Computer Science and Engineering	on	Avinesh			
312	18CS8145	18U10569	Bachelor of Technology in	Computer Science and Engineering	on	Paritosh Mahapatra			
313	18CS8146	18U10572	Bachelor of Technology in	Computer Science and Engineering	on	Ayush Gupta			
314	18CS8147	18U10585	Bachelor of Technology in	Computer Science and Engineering	on	Mogali Raghu Ram			
315	18CS8148	18U10596	Bachelor of Technology in	Computer Science and Engineering	on	Sripada Yaswanth Kalyan			
316	18CS8149	18U10610	Bachelor of Technology in	Computer Science and Engineering	on	Vaddavalli Sai Sita Ram			
317	18CS8150	18U10622	Bachelor of Technology in	Computer Science and Engineering	on	Abhishek Rangana			
318	18CS8151	18U10630	Bachelor of Technology in	Computer Science and Engineering	on	Utkarsh Agarwal			
319	18CS8152	18U10645	Bachelor of Technology in	Computer Science and Engineering	on	Deepak Kumar			
320	18CS8153	18U10646	Bachelor of Technology in	Computer Science and Engineering	on	Dalu Ajay Prashanth			
321	18CS8154	18U10649	Bachelor of Technology in	Computer Science and Engineering	on	Rana Dilendra Singh			
322	18CS8155	18U10657	Bachelor of Technology in	Computer Science and Engineering	on	Shubhankar Chakrabarty			
323	18CS8156	18U10660	Bachelor of Technology in	Computer Science and Engineering	on	Khan Azhar			
324	18CS8157	18U10666	Bachelor of Technology in	Computer Science and Engineering	on	Rahul Lodha			
325	18CS8158	18U10709	Bachelor of Technology in	Computer Science and Engineering	on	Gottapu Geeta Deepika			
326	18CS8159	18U10727	Bachelor of Technology in	Computer Science and Engineering	on	Erikipati Karthik			
327	18CS8160	18U10737	Bachelor of Technology in	Computer Science and Engineering	on	Dhiraj Chaurasia			
328	18CS8161	18U10742	Bachelor of Technology in	Computer Science and Engineering	on	Simhavishnu Ram Prasad			
329	18CS8162	18U10743	Bachelor of Technology in	Computer Science and Engineering	on	Binita Karmakar			
330	18CS8163	18U10748	Bachelor of Technology in	Computer Science and Engineering	on	Snehit Mishra			

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331	18CS8164	18U10751	Bachelor of Technology in	Computer Science and Engineering	on	Depankar Bisoy			
332	18CS8165	18U10759	Bachelor of Technology in	Computer Science and Engineering	on	Anto Prathik Savio Pravin			
333	18CS8166	18U10764	Bachelor of Technology in	Computer Science and Engineering	on	Vimal Kumar Dubey			
334	18EC8001	18U10015	Bachelor of Technology in	Electronics and Communication Engineering	on	Adarsh Verma			
335	18EC8002	18U10023	Bachelor of Technology in	Electronics and Communication Engineering	on	Vikash Kumar Yadav			
336	18EC8003	18U10025	Bachelor of Technology in	Electronics and Communication Engineering	on	Mithilesh Halder			
337	18EC8004	18U10028	Bachelor of Technology in	Electronics and Communication Engineering	on	Jyotishka Dasgupta			
338	18EC8005	18U10029	Bachelor of Technology in	Electronics and Communication Engineering	on	Koushik Karmakar			
339	18EC8006	18U10032	Bachelor of Technology in	Electronics and Communication Engineering	on	Sujana Pal			
340	18EC8007	18U10034	Bachelor of Technology in	Electronics and Communication Engineering	on	Surajit Mondal			
341	18EC8008	18U10039	Bachelor of Technology in	Electronics and Communication Engineering	on	Koushik Kumar Das			
342	18EC8009	18U10043	Bachelor of Technology in	Electronics and Communication Engineering	on	Priya			
343	18EC8010	18U10060	Bachelor of Technology in	Electronics and Communication Engineering	on	Avinash Kumar			
344	18EC8011	18U10070	Bachelor of Technology in	Electronics and Communication Engineering	on	Hrithik Panda			
345	18EC8012	18U10084	Bachelor of Technology in	Electronics and Communication Engineering	on	Dipak Biswakarma			
346	18EC8013	18U10091	Bachelor of Technology in	Electronics and Communication Engineering	on	Brinta Das			
347	18EC8014	18U10101	Bachelor of Technology in	Electronics and Communication Engineering	on	Abhishek Narayan Sarkar			
348	18EC8015	18U10112	Bachelor of Technology in	Electronics and Communication Engineering	on	Geetha Charan Duba			
349	18EC8016	18U10133	Bachelor of Technology in	Electronics and Communication Engineering	on	Aratla Pavani			
350	18EC8018	18U10154	Bachelor of Technology in	Electronics and Communication Engineering	on	Ayushman Banerjee			
351	18EC8020	18U10188	Bachelor of Technology in	Electronics and Communication Engineering	on	Anusha Ghosh			
352	18EC8021	18U10198	Bachelor of Technology in	Electronics and Communication Engineering	on	Pritam Kumar Biswas			

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353	18EC8022	18U10228	Bachelor of Technology in	Electronics and Communication Engineering	on	Hridoy Sutar			
354	18EC8023	18U10231	Bachelor of Technology in	Electronics and Communication Engineering	on	Abhishek Kumar Jaiswal			
355	18EC8024	18U10232	Bachelor of Technology in	Electronics and Communication Engineering	on	Sweta Rakhecha			
356	18EC8025	18U10235	Bachelor of Technology in	Electronics and Communication Engineering	on	Burada Teja Ashok			
357	18EC8026	18U10237	Bachelor of Technology in	Electronics and Communication Engineering	on	Syed Ziaul Islam			
358	18EC8027	18U10244	Bachelor of Technology in	Electronics and Communication Engineering	on	Kodali Likhitha			
359	18EC8028	18U10260	Bachelor of Technology in	Electronics and Communication Engineering	on	Promit Roy			
360	18EC8029	18U10284	Bachelor of Technology in	Electronics and Communication Engineering	on	Daggupati Bala Sai Pavan Kumar			
361	18EC8030	18U10292	Bachelor of Technology in	Electronics and Communication Engineering	on	Sourav Kumar Shaw			
362	18EC8031	18U10301	Bachelor of Technology in	Electronics and Communication Engineering	on	Nitisha Singh			
363	18EC8032	18U10303	Bachelor of Technology in	Electronics and Communication Engineering	on	Pritish Singhal			
364	18EC8033	18U10306	Bachelor of Technology in	Electronics and Communication Engineering	on	Soumya Chatterjee			
365	18EC8034	18U10308	Bachelor of Technology in	Electronics and Communication Engineering	on	Vivek Sharma			
366	18EC8035	18U10310	Bachelor of Technology in	Electronics and Communication Engineering	on	Kolluru Sai Charan			
367	18EC8036	18U10325	Bachelor of Technology in	Electronics and Communication Engineering	on	Vithanala Yamini			
368	18EC8037	18U10329	Bachelor of Technology in	Electronics and Communication Engineering	on	Mohammad Ashir			
369	18EC8038	18U10330	Bachelor of Technology in	Electronics and Communication Engineering	on	Dunna Rajeev Prakash			
370	18EC8039	18U10334	Bachelor of Technology in	Electronics and Communication Engineering	on	Bandi Mani Shankar			
371	18EC8040	18U10339	Bachelor of Technology in	Electronics and Communication Engineering	on	Gummidi Vamsi Sai Madhu			
372	18EC8041	18U10343	Bachelor of Technology in	Electronics and Communication Engineering	on	Ankit Chauhan			
373	18EC8042	18U10353	Bachelor of Technology in	Electronics and Communication Engineering	on	Mandru Sanjay Kumar			
374	18EC8043	18U10362	Bachelor of Technology in	Electronics and Communication Engineering	on	Vinay Kushapuram			

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375	18EC8044	18U10365	Bachelor of Technology in	Electronics and Communication Engineering	on	Donthireddy Dinesh Reddy			
376	18EC8045	18U10371	Bachelor of Technology in	Electronics and Communication Engineering	on	Yash Vishnoi			
377	18EC8046	18U10377	Bachelor of Technology in	Electronics and Communication Engineering	on	Shashank Singh			
378	18EC8047	18U10387	Bachelor of Technology in	Electronics and Communication Engineering	on	Sanjoy Mallick			
379	18EC8048	18U10395	Bachelor of Technology in	Electronics and Communication Engineering	on	Samujjal Suni Mochahari			
380	18EC8049	18U10406	Bachelor of Technology in	Electronics and Communication Engineering	on	Pawan Kumar			
381	18EC8050	18U10410	Bachelor of Technology in	Electronics and Communication Engineering	on	Sanumala Moses			
382	18EC8051	18U10414	Bachelor of Technology in	Electronics and Communication Engineering	on	Uppada Bhanu Reddy			
383	18EC8052	18U10419	Bachelor of Technology in	Electronics and Communication Engineering	on	Singineedi Sainath			
384	18EC8053	18U10421	Bachelor of Technology in	Electronics and Communication Engineering	on	Ayush Abhishek Kujur			
385	18EC8054	18U10422	Bachelor of Technology in	Electronics and Communication Engineering	on	Kusumanchi V Satya Surya Kalki Rakesh			
386	18EC8055	18U10423	Bachelor of Technology in	Electronics and Communication Engineering	on	Kondapi V S Krishna Praveen			
387	18EC8056	18U10425	Bachelor of Technology in	Electronics and Communication Engineering	on	Perimi Vishnu Vardhan			
388	18EC8057	18U10439	Bachelor of Technology in	Electronics and Communication Engineering	on	Nareddy Abhinay Kumar Reddy			
389	18EC8058	18U10454	Bachelor of Technology in	Electronics and Communication Engineering	on	Madhumita Mandal			
390	18EC8059	18U10456	Bachelor of Technology in	Electronics and Communication Engineering	on	Neharika Shah			
391	18EC8060	18U10471	Bachelor of Technology in	Electronics and Communication Engineering	on	Munshi Ajfar Rahaman			
392	18EC8061	18U10478	Bachelor of Technology in	Electronics and Communication Engineering	on	Inaganti Kashyap			
393	18EC8062	18U10480	Bachelor of Technology in	Electronics and Communication Engineering	on	Mukesh Kumar Gupta			
394	18EC8063	18U10485	Bachelor of Technology in	Electronics and Communication Engineering	on	Animesh Datta			
395	18EC8064	18U10486	Bachelor of Technology in	Electronics and Communication Engineering	on	Chowdhury Arunima Nishi			
396	18EC8065	18U10493	Bachelor of Technology in	Electronics and Communication Engineering	on	Satti Jyothi			

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397	18EC8067	18U10529	Bachelor of Technology in	Electronics and Communication Engineering	on	Rounak Das			
398	18EC8068	18U10555	Bachelor of Technology in	Electronics and Communication Engineering	on	Shankar Das Banerjee			
399	18EC8069	18U10581	Bachelor of Technology in	Electronics and Communication Engineering	on	Aman Kumar			
400	18EC8070	18U10598	Bachelor of Technology in	Electronics and Communication Engineering	on	Rathindra Nath Ghosh			
401	18EC8071	18U10600	Bachelor of Technology in	Electronics and Communication Engineering	on	Sangu Manideep Reddy			
402	18EC8072	18U10603	Bachelor of Technology in	Electronics and Communication Engineering	on	Sahaj Kumar Jha			
403	18EC8073	18U10605	Bachelor of Technology in	Electronics and Communication Engineering	on	Pranjal Mittal			
404	18EC8074	18U10611	Bachelor of Technology in	Electronics and Communication Engineering	on	Nim Lhamu Sherpa			
405	18EC8075	18U10621	Bachelor of Technology in	Electronics and Communication Engineering	on	Konda Chandra Sekhar			
406	18EC8076	18U10634	Bachelor of Technology in	Electronics and Communication Engineering	on	Vivek Gupta			
407	18EC8077	18U10690	Bachelor of Technology in	Electronics and Communication Engineering	on	Havila Delight Boddepalli			
408	18EC8078	18U10701	Bachelor of Technology in	Electronics and Communication Engineering	on	Rahul Mohata			
409	18EC8079	18U10702	Bachelor of Technology in	Electronics and Communication Engineering	on	Yamavaram Sree Shivani			
410	18EC8080	18U10714	Bachelor of Technology in	Electronics and Communication Engineering	on	Kapu Sharath Kumar Reddy			
411	18EC8081	18U10728	Bachelor of Technology in	Electronics and Communication Engineering	on	Johnny Living Ston.Jakkula			
412	18EC8082	18U10747	Bachelor of Technology in	Electronics and Communication Engineering	on	Urvashi			
413	18EC8083	18U10753	Bachelor of Technology in	Electronics and Communication Engineering	on	Abhishek Bose			
414	18EC8084	18U10763	Bachelor of Technology in	Electronics and Communication Engineering	on	Atul Kumar Tiwari			
415	18EC8085	18U10766	Bachelor of Technology in	Electronics and Communication Engineering	on	Saurabh Singh			
416	18EE8001	18U10009	Bachelor of Technology in	Electrical Engineering	on	Tanushree Dey			
417	18EE8002	18U10012	Bachelor of Technology in	Electrical Engineering	on	Doyel Maji			
418	18EE8003	18U10014	Bachelor of Technology in	Electrical Engineering	on	Prakash Kumar Hansda			

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419	18EE8004	18U10024	Bachelor of Technology in	Electrical Engineering	on	Parre Yashwanth			
420	18EE8005	18U10027	Bachelor of Technology in	Electrical Engineering	on	Kabyajyoti Biswas			
421	18EE8006	18U10036	Bachelor of Technology in	Electrical Engineering	on	Adhisha Roy			
422	18EE8007	18U10047	Bachelor of Technology in	Electrical Engineering	on	Shubham Jaiswal			
423	18EE8008	18U10050	Bachelor of Technology in	Electrical Engineering	on	Rahul Karmakar			
424	18EE8009	18U10065	Bachelor of Technology in	Electrical Engineering	on	Arnab Ari			
425	18EE8010	18U10074	Bachelor of Technology in	Electrical Engineering	on	Subhra Ranjan Karmakar			
426	18EE8011	18U10076	Bachelor of Technology in	Electrical Engineering	on	Soumyajit Saha			
427	18EE8012	18U10093	Bachelor of Technology in	Electrical Engineering	on	Vinita Singh			
428	18EE8013	18U10095	Bachelor of Technology in	Electrical Engineering	on	Biswajit Rout			
429	18EE8014	18U10098	Bachelor of Technology in	Electrical Engineering	on	Akash Kumar Gupta			
430	18EE8015	18U10103	Bachelor of Technology in	Electrical Engineering	on	Sujoy Sankar Ghosh			
431	18EE8016	18U10114	Bachelor of Technology in	Electrical Engineering	on	Lekh Ram			
432	18EE8017	18U10123	Bachelor of Technology in	Electrical Engineering	on	Rahul Kumar			
433	18EE8018	18U10125	Bachelor of Technology in	Electrical Engineering	on	Srijan Roy			
434	18EE8019	18U10130	Bachelor of Technology in	Electrical Engineering	on	Abhishek Malakar			
435	18EE8020	18U10156	Bachelor of Technology in	Electrical Engineering	on	Subhankar Datta			
436	18EE8021	18U10163	Bachelor of Technology in	Electrical Engineering	on	Shubham Banjare			
437	18EE8022	18U10173	Bachelor of Technology in	Electrical Engineering	on	Deepak			
438	18EE8023	18U10177	Bachelor of Technology in	Electrical Engineering	on	Sankhomala Hansda			
439	18EE8024	18U10183	Bachelor of Technology in	Electrical Engineering	on	Sayan Mondal			
440	18EE8025	18U10194	Bachelor of Technology in	Electrical Engineering	on	Sai Raghava Kailasa			

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441	18EE8026	18U10205	Bachelor of Technology in	Electrical Engineering	on	Sourav Chakraborty			
442	18EE8027	18U10210	Bachelor of Technology in	Electrical Engineering	on	Rochisnu Dutta			
443	18EE8028	18U10213	Bachelor of Technology in	Electrical Engineering	on	Suraj Kumar			
444	18EE8029	18U10215	Bachelor of Technology in	Electrical Engineering	on	Shubhajyoti Mondal			
445	18EE8030	18U10217	Bachelor of Technology in	Electrical Engineering	on	Srijit Majumder			
446	18EE8032	18U10230	Bachelor of Technology in	Electrical Engineering	on	Gorripati Divya Sai Priya			
447	18EE8033	18U10239	Bachelor of Technology in	Electrical Engineering	on	Maumita Basu			
448	18EE8034	18U10245	Bachelor of Technology in	Electrical Engineering	on	Nagaraboina Yashwanth			
449	18EE8036	18U10249	Bachelor of Technology in	Electrical Engineering	on	Ashif Ahafaj Laskar			
450	18EE8037	18U10257	Bachelor of Technology in	Electrical Engineering	on	Sakshi Paswan			
451	18EE8038	18U10258	Bachelor of Technology in	Electrical Engineering	on	Souvik Mandal			
452	18EE8039	18U10263	Bachelor of Technology in	Electrical Engineering	on	Rishabh Srivastava			
453	18EE8040	18U10265	Bachelor of Technology in	Electrical Engineering	on	Soumya Hembram			
454	18EE8041	18U10268	Bachelor of Technology in	Electrical Engineering	on	Kapish Luhariwala			
455	18EE8042	18U10282	Bachelor of Technology in	Electrical Engineering	on	Sandip Pramanik			
456	18EE8043	18U10312	Bachelor of Technology in	Electrical Engineering	on	Vishal Kumar			
457	18EE8044	18U10313	Bachelor of Technology in	Electrical Engineering	on	Yedala Aravind Kumar Reddy			
458	18EE8045	18U10315	Bachelor of Technology in	Electrical Engineering	on	Soumyadeep Saha			
459	18EE8046	18U10342	Bachelor of Technology in	Electrical Engineering	on	Agnivo Palit			
460	18EE8047	18U10348	Bachelor of Technology in	Electrical Engineering	on	Suchismita Nayak			
461	18EE8048	18U10354	Bachelor of Technology in	Electrical Engineering	on	Tamendra Kumar Sahu			
462	18EE8049	18U10356	Bachelor of Technology in	Electrical Engineering	on	Ajit Dhayal			

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463	18EE8050	18U10393	Bachelor of Technology in	Electrical Engineering	on	Anand Kharwar			
464	18EE8051	18U10405	Bachelor of Technology in	Electrical Engineering	on	Guntumani Jayaprakash Yadav			
465	18EE8052	18U10408	Bachelor of Technology in	Electrical Engineering	on	Kapil			
466	18EE8053	18U10412	Bachelor of Technology in	Electrical Engineering	on	Chavva Praneeth Kumar Reddy			
467	18EE8054	18U10415	Bachelor of Technology in	Electrical Engineering	on	Pradeep Kumar			
468	18EE8055	18U10418	Bachelor of Technology in	Electrical Engineering	on	Bheem Singh Meena			
469	18EE8056	18U10428	Bachelor of Technology in	Electrical Engineering	on	Nabha Venkata Naga Deepthi			
470	18EE8057	18U10461	Bachelor of Technology in	Electrical Engineering	on	Rathod Lipi Akanksha			
471	18EE8058	18U10464	Bachelor of Technology in	Electrical Engineering	on	Enugu Shashivardhan			
472	18EE8059	18U10481	Bachelor of Technology in	Electrical Engineering	on	Biraj Roy			
473	18EE8060	18U10502	Bachelor of Technology in	Electrical Engineering	on	Aman Singh			
474	18EE8061	18U10518	Bachelor of Technology in	Electrical Engineering	on	Shakti Tiwari			
475	18EE8062	18U10533	Bachelor of Technology in	Electrical Engineering	on	Madhura Ghosh			
476	18EE8063	18U10534	Bachelor of Technology in	Electrical Engineering	on	Koppadi Hemanth Narasimha Varma			
477	18EE8064	18U10545	Bachelor of Technology in	Electrical Engineering	on	Prataparao Sai Bhavya Teja			
478	18EE8065	18U10560	Bachelor of Technology in	Electrical Engineering	on	Sayak Acharya			
479	18EE8066	18U10563	Bachelor of Technology in	Electrical Engineering	on	Soham Samanta			
480	18EE8067	18U10564	Bachelor of Technology in	Electrical Engineering	on	Kakileti Sriram			
481	18EE8068	18U10567	Bachelor of Technology in	Electrical Engineering	on	Bhukya Vamshi			
482	18EE8069	18U10587	Bachelor of Technology in	Electrical Engineering	on	Immadisetty Lakshmi Bhagya Rajendra Kumar			
483	18EE8070	18U10595	Bachelor of Technology in	Electrical Engineering	on	Khushi Bansal			
484	18EE8071	18U10617	Bachelor of Technology in	Electrical Engineering	on	Rajkumar Halder			

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485	18EE8072	18U10636	Bachelor of Technology in	Electrical Engineering	on	Deepmoy Hazra			
486	18EE8073	18U10668	Bachelor of Technology in	Electrical Engineering	on	Piyush Satnaliwala			
487	18EE8074	18U10673	Bachelor of Technology in	Electrical Engineering	on	Ambika Biswas Neela			
488	18EE8075	18U10676	Bachelor of Technology in	Electrical Engineering	on	Devidas Panday			
489	18EE8076	18U10692	Bachelor of Technology in	Electrical Engineering	on	Vanamu Giridhar Kumar			
490	18EE8077	18U10694	Bachelor of Technology in	Electrical Engineering	on	Kumar Gourav			
491	18EE8078	18U10711	Bachelor of Technology in	Electrical Engineering	on	Anushka Agrawal			
492	18EE8079	18U10712	Bachelor of Technology in	Electrical Engineering	on	Prakhar Srivastava			
493	18EE8080	18U10722	Bachelor of Technology in	Electrical Engineering	on	Palavalasa Hima Sekhar			
494	18EE8081	18U10749	Bachelor of Technology in	Electrical Engineering	on	Shreya Marwaha			
495	18EE8082	18U10750	Bachelor of Technology in	Electrical Engineering	on	Akhilesh Karan Chaudhari			
496	18EE8083	18U10755	Bachelor of Technology in	Electrical Engineering	on	Shashikant Tiwari			
497	18EE8084	18U10757	Bachelor of Technology in	Electrical Engineering	on	Vishal Brahma			
498	18EE8085	18U10200	Bachelor of Technology in	Electrical Engineering	on	Balivada Sree Varsha			
499	17IT8022	17U10185	Bachelor of Technology in	Information Technology	on	Chiranjeet Gorai			
500	18ME8001	18U10003	Bachelor of Technology in	Mechanical Engineering	on	Dipayan Dalal			
501	18ME8002	18U10005	Bachelor of Technology in	Mechanical Engineering	on	Ripan Kundu			
502	18ME8003	18U10008	Bachelor of Technology in	Mechanical Engineering	on	Sucharu Rai			
503	18ME8004	18U10010	Bachelor of Technology in	Mechanical Engineering	on	Hridoy Halder			
504	18ME8005	18U10017	Bachelor of Technology in	Mechanical Engineering	on	Anunita Das			
505	18ME8006	18U10030	Bachelor of Technology in	Mechanical Engineering	on	Surojit Tudu			
506	18ME8007	18U10031	Bachelor of Technology in	Mechanical Engineering	on	Aman Agarwal			

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507	18ME8008	18U10037	Bachelor of Technology in	Mechanical Engineering	on	Suman Guin			
508	18ME8009	18U10041	Bachelor of Technology in	Mechanical Engineering	on	Mriganka Bagchi			
509	18ME8010	18U10044	Bachelor of Technology in	Mechanical Engineering	on	Anuragh Tamang			
510	18ME8011	18U10057	Bachelor of Technology in	Mechanical Engineering	on	Ananya Nath			
511	18ME8012	18U10068	Bachelor of Technology in	Mechanical Engineering	on	Argha Gayen			
512	18ME8013	18U10075	Bachelor of Technology in	Mechanical Engineering	on	Sourasish Kundu			
513	18ME8015	18U10081	Bachelor of Technology in	Mechanical Engineering	on	Allada Navdeep			
514	18ME8016	18U10088	Bachelor of Technology in	Mechanical Engineering	on	Rudraneel Sarkar			
515	18ME8017	18U10090	Bachelor of Technology in	Mechanical Engineering	on	Sheetal Tamang			
516	18ME8018	18U10094	Bachelor of Technology in	Mechanical Engineering	on	Jayanta Roy			
517	18ME8019	18U10096	Bachelor of Technology in	Mechanical Engineering	on	Anuvab Das			
518	18ME8020	18U10106	Bachelor of Technology in	Mechanical Engineering	on	Ankita Singha			
519	18ME8021	18U10107	Bachelor of Technology in	Mechanical Engineering	on	Harshit			
520	18ME8022	18U10108	Bachelor of Technology in	Mechanical Engineering	on	Debargha Ghosh			
521	18ME8023	18U10111	Bachelor of Technology in	Mechanical Engineering	on	Koushik Dutta			
522	18ME8024	18U10120	Bachelor of Technology in	Mechanical Engineering	on	Naveen Sah			
523	18ME8025	18U10121	Bachelor of Technology in	Mechanical Engineering	on	Tamoghna Basak			
524	18ME8026	18U10126	Bachelor of Technology in	Mechanical Engineering	on	Soumyadeep Saha			
525	18ME8027	18U10131	Bachelor of Technology in	Mechanical Engineering	on	Sumit Mishra			
526	18ME8028	18U10132	Bachelor of Technology in	Mechanical Engineering	on	Sanjana Roy			
527	18ME8029	18U10138	Bachelor of Technology in	Mechanical Engineering	on	Vanumu Khyatirmaye			
528	18ME8030	18U10140	Bachelor of Technology in	Mechanical Engineering	on	Subhrasnata Chakraborty			

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529	18ME8031	18U10141	Bachelor of Technology in	Mechanical Engineering	on	Himadri Dutta			
530	18ME8032	18U10143	Bachelor of Technology in	Mechanical Engineering	on	Amit Das Adhikary			
531	18ME8033	18U10145	Bachelor of Technology in	Mechanical Engineering	on	Kalyanam Vineeth Kumar			
532	18ME8034	18U10147	Bachelor of Technology in	Mechanical Engineering	on	Md. Meraj			
533	18ME8035	18U10155	Bachelor of Technology in	Mechanical Engineering	on	Anshu Yadav			
534	18ME8036	18U10158	Bachelor of Technology in	Mechanical Engineering	on	Theella Leela Shyam Kumar			
535	18ME8037	18U10160	Bachelor of Technology in	Mechanical Engineering	on	Rakesh Mandal			
536	18ME8038	18U10165	Bachelor of Technology in	Mechanical Engineering	on	Sudeep Saw			
537	18ME8039	18U10169	Bachelor of Technology in	Mechanical Engineering	on	Gaurav Bhagat			
538	18ME8040	18U10171	Bachelor of Technology in	Mechanical Engineering	on	Puja Kumari			
539	18ME8041	18U10176	Bachelor of Technology in	Mechanical Engineering	on	Kirti Kumari			
540	18ME8042	18U10180	Bachelor of Technology in	Mechanical Engineering	on	Akash Dandapat			
541	18ME8043	18U10181	Bachelor of Technology in	Mechanical Engineering	on	Unmish Bag			
542	18ME8044	18U10184	Bachelor of Technology in	Mechanical Engineering	on	Arko Sarkar			
543	18ME8045	18U10189	Bachelor of Technology in	Mechanical Engineering	on	Shivam			
544	18ME8046	18U10199	Bachelor of Technology in	Mechanical Engineering	on	Regidi Vijay Kumar			
545	18ME8048	18U10204	Bachelor of Technology in	Mechanical Engineering	on	Bandaru Vishnu Venkata Patrudu			
546	18ME8049	18U10206	Bachelor of Technology in	Mechanical Engineering	on	Amit Tiwari			
547	18ME8050	18U10209	Bachelor of Technology in	Mechanical Engineering	on	Bhavya Vashishtha			
548	18ME8051	18U10212	Bachelor of Technology in	Mechanical Engineering	on	Bheemarasetty Lakshmi Deepak			
549	18ME8052	18U10220	Bachelor of Technology in	Mechanical Engineering	on	Ankit Kumar Pandey			
550	18ME8053	18U10221	Bachelor of Technology in	Mechanical Engineering	on	Soumyadip Biswas			

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551	18ME8054	18U10225	Bachelor of Technology in	Mechanical Engineering	on	Subhendu Sekhar Bag			
552	18ME8055	18U10234	Bachelor of Technology in	Mechanical Engineering	on	Dhrubajyoti Kumar			
553	18ME8057	18U10241	Bachelor of Technology in	Mechanical Engineering	on	Gande Pranay Kumar			
554	18ME8058	18U10251	Bachelor of Technology in	Mechanical Engineering	on	Abhishek Singh			
555	18ME8059	18U10256	Bachelor of Technology in	Mechanical Engineering	on	Ariga Achyutha Sushanth			
556	18ME8060	18U10267	Bachelor of Technology in	Mechanical Engineering	on	Zidan Hossain			
557	18ME8061	18U10269	Bachelor of Technology in	Mechanical Engineering	on	Pratik Debnath			
558	18ME8062	18U10275	Bachelor of Technology in	Mechanical Engineering	on	Reddy Jyothendra Sai Durga Sankar			
559	18ME8063	18U10276	Bachelor of Technology in	Mechanical Engineering	on	Kaustuv Gandhi			
560	18ME8064	18U10278	Bachelor of Technology in	Mechanical Engineering	on	Boddu Siva Nageswa Rao			
561	18ME8066	18U10309	Bachelor of Technology in	Mechanical Engineering	on	Terli Girishma			
562	18ME8067	18U10321	Bachelor of Technology in	Mechanical Engineering	on	Rishab Verma			
563	18ME8068	18U10324	Bachelor of Technology in	Mechanical Engineering	on	Nuthangi Rahul			
564	18ME8069	18U10326	Bachelor of Technology in	Mechanical Engineering	on	Sonu Kumar			
565	18ME8070	18U10331	Bachelor of Technology in	Mechanical Engineering	on	Priyanshu			
566	18ME8072	18U10337	Bachelor of Technology in	Mechanical Engineering	on	Rohit Upreti			
567	18ME8073	18U10341	Bachelor of Technology in	Mechanical Engineering	on	Punya Chandra Arjya			
568	18ME8074	18U10347	Bachelor of Technology in	Mechanical Engineering	on	Vandakiya Abhishek			
569	18ME8075	18U10349	Bachelor of Technology in	Mechanical Engineering	on	S Rishi Chand			
570	18ME8076	18U10351	Bachelor of Technology in	Mechanical Engineering	on	Charugundla Manikanta Ganesh			
571	18ME8077	18U10357	Bachelor of Technology in	Mechanical Engineering	on	Anubhav			
572	18ME8078	18U10360	Bachelor of Technology in	Mechanical Engineering	on	Sourav Soo			

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573	18ME8079	18U10367	Bachelor of Technology in	Mechanical Engineering	on	Kokkiripati Neeharika			
574	18ME8080	18U10368	Bachelor of Technology in	Mechanical Engineering	on	Rishab Kumar			
575	18ME8081	18U10370	Bachelor of Technology in	Mechanical Engineering	on	Aakash Dey			
576	18ME8082	18U10380	Bachelor of Technology in	Mechanical Engineering	on	Vivek Kumar Shah			
577	18ME8083	18U10394	Bachelor of Technology in	Mechanical Engineering	on	Ryali Hyndavi			
578	18ME8084	18U10398	Bachelor of Technology in	Mechanical Engineering	on	Debabrata Moi			
579	18ME8085	18U10411	Bachelor of Technology in	Mechanical Engineering	on	Salihundam Simhakoushik			
580	18ME8086	18U10413	Bachelor of Technology in	Mechanical Engineering	on	Galla Tharun Kumar			
581	18ME8087	18U10417	Bachelor of Technology in	Mechanical Engineering	on	Shreyashkar Lal Sahu			
582	18ME8088	18U10426	Bachelor of Technology in	Mechanical Engineering	on	Kalpam Sushith			
583	18ME8089	18U10430	Bachelor of Technology in	Mechanical Engineering	on	Vraj Kartik Desai			
584	18ME8090	18U10431	Bachelor of Technology in	Mechanical Engineering	on	Mayank Dandwani			
585	18ME8091	18U10435	Bachelor of Technology in	Mechanical Engineering	on	Karumajji Soma Sundar			
586	18ME8092	18U10437	Bachelor of Technology in	Mechanical Engineering	on	Kuddapu Ashish Kumar			
587	18ME8093	18U10449	Bachelor of Technology in	Mechanical Engineering	on	Shubham Agarwal			
588	18ME8094	18U10450	Bachelor of Technology in	Mechanical Engineering	on	Dasam Prudhvi			
589	18ME8095	18U10451	Bachelor of Technology in	Mechanical Engineering	on	Chetan Gupta			
590	18ME8096	18U10460	Bachelor of Technology in	Mechanical Engineering	on	Bighnesh Mohanty			
591	18ME8097	18U10465	Bachelor of Technology in	Mechanical Engineering	on	Thamarbha Jeevitha			
592	18ME8098	18U10469	Bachelor of Technology in	Mechanical Engineering	on	Vivek Kumar			
593	18ME8099	18U10470	Bachelor of Technology in	Mechanical Engineering	on	Sachin Rawat			
594	18ME8100	18U10474	Bachelor of Technology in	Mechanical Engineering	on	Jovin Litto			

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595	18ME8101	18U10477	Bachelor of Technology in	Mechanical Engineering	on	Soumik Kumar Hazra			
596	18ME8102	18U10479	Bachelor of Technology in	Mechanical Engineering	on	Soumyajit Ganguly			
597	18ME8103	18U10490	Bachelor of Technology in	Mechanical Engineering	on	Ankita Mishra			
598	18ME8104	18U10492	Bachelor of Technology in	Mechanical Engineering	on	Suraj Kumar Sahoo			
599	18ME8105	18U10520	Bachelor of Technology in	Mechanical Engineering	on	Akash Sharma			
600	18ME8106	18U10524	Bachelor of Technology in	Mechanical Engineering	on	Koka Sai Saketh			
601	18ME8107	18U10525	Bachelor of Technology in	Mechanical Engineering	on	V Vishesh			
602	18ME8108	18U10526	Bachelor of Technology in	Mechanical Engineering	on	Rangeet Hait			
603	18ME8109	18U10532	Bachelor of Technology in	Mechanical Engineering	on	Adrija Biswas			
604	18ME8110	18U10535	Bachelor of Technology in	Mechanical Engineering	on	Rittick Purkait			
605	18ME8111	18U10539	Bachelor of Technology in	Mechanical Engineering	on	Souvik Bose			
606	18ME8112	18U10542	Bachelor of Technology in	Mechanical Engineering	on	Soumyadeep Mondal			
607	18ME8113	18U10546	Bachelor of Technology in	Mechanical Engineering	on	Arabelli Sriram Reddy			
608	18ME8114	18U10552	Bachelor of Technology in	Mechanical Engineering	on	Madhav Jha			
609	18ME8116	18U10557	Bachelor of Technology in	Mechanical Engineering	on	Sauhardo Roy			
610	18ME8117	18U10568	Bachelor of Technology in	Mechanical Engineering	on	Rik Dasgupta			
611	18ME8118	18U10570	Bachelor of Technology in	Mechanical Engineering	on	Khandavalli Dinesh			
612	18ME8119	18U10580	Bachelor of Technology in	Mechanical Engineering	on	Mukul Anand			
613	18ME8120	18U10588	Bachelor of Technology in	Mechanical Engineering	on	R Pavan Kumar			
614	18ME8121	18U10590	Bachelor of Technology in	Mechanical Engineering	on	Arnab Roy Chowdhury			
615	18ME8122	18U10591	Bachelor of Technology in	Mechanical Engineering	on	Anushka Sen			
616	18ME8123	18U10593	Bachelor of Technology in	Mechanical Engineering	on	Aryan Kanu			

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617	18ME8124	18U10608	Bachelor of Technology in	Mechanical Engineering	on	Immandi Pavan Preetham			
618	18ME8125	18U10612	Bachelor of Technology in	Mechanical Engineering	on	Malyadeep Bhattacharya			
619	18ME8127	18U10623	Bachelor of Technology in	Mechanical Engineering	on	Somarya Bhattacharyya			
620	18ME8128	18U10624	Bachelor of Technology in	Mechanical Engineering	on	Ashis Srivastava			
621	18ME8129	18U10625	Bachelor of Technology in	Mechanical Engineering	on	Siddhant S Barman			
622	18ME8130	18U10631	Bachelor of Technology in	Mechanical Engineering	on	Aditya Kumar Chaubey			
623	18ME8131	18U10638	Bachelor of Technology in	Mechanical Engineering	on	Ankan Chakraborty			
624	18ME8132	18U10650	Bachelor of Technology in	Mechanical Engineering	on	Ishika Chowdhury			
625	18ME8133	18U10654	Bachelor of Technology in	Mechanical Engineering	on	Shubhangee			
626	18ME8134	18U10655	Bachelor of Technology in	Mechanical Engineering	on	Apurba Mondal			
627	18ME8135	18U10656	Bachelor of Technology in	Mechanical Engineering	on	Dabbiru Rohit Kumar			
628	18ME8136	18U10659	Bachelor of Technology in	Mechanical Engineering	on	Kiran P Abraham			
629	18ME8137	18U10662	Bachelor of Technology in	Mechanical Engineering	on	Mohith Vardhan Baswa			
630	18ME8138	18U10667	Bachelor of Technology in	Mechanical Engineering	on	Shaik Gouse Mastan			
631	18ME8139	18U10671	Bachelor of Technology in	Mechanical Engineering	on	Divyanshu Bajpai			
632	18ME8140	18U10675	Bachelor of Technology in	Mechanical Engineering	on	A S M Norul Amin			
633	18ME8141	18U10678	Bachelor of Technology in	Mechanical Engineering	on	Shivam Gangwar			
634	18ME8142	18U10679	Bachelor of Technology in	Mechanical Engineering	on	Pachava Lohitha			
635	18ME8143	18U10684	Bachelor of Technology in	Mechanical Engineering	on	Gagan Prasad Gautam			
636	18ME8144	18U10715	Bachelor of Technology in	Mechanical Engineering	on	Ankit Lunia			
637	18ME8145	18U10716	Bachelor of Technology in	Mechanical Engineering	on	Shivam			
638	18ME8146	18U10717	Bachelor of Technology in	Mechanical Engineering	on	Mekala Purushottam			

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639	18ME8147	18U10720	Bachelor of Technology in	Mechanical Engineering	on	Piyush Yadav			
640	18ME8149	18U10724	Bachelor of Technology in	Mechanical Engineering	on	Nagireddi Mounica			
641	18ME8150	18U10725	Bachelor of Technology in	Mechanical Engineering	on	Vankudoth Pranay			
642	18ME8152	18U10741	Bachelor of Technology in	Mechanical Engineering	on	Roshan Kumar			
643	18ME8153	18U10745	Bachelor of Technology in	Mechanical Engineering	on	Snigdha Behera			
644	18ME8154	18U10752	Bachelor of Technology in	Mechanical Engineering	on	Aadarsh Kumar Mishra			
645	18ME8156	18U10758	Bachelor of Technology in	Mechanical Engineering	on	Tripti Kona Biswas			
646	18ME8157	18U10186	Bachelor of Technology in	Mechanical Engineering	on	Nilabro Saha			
647	18ME8158	18U10193	Bachelor of Technology in	Mechanical Engineering	on	Sanniva Bhattacharjee			
648	11/ME/118	20110520	Bachelor of Technology in	Mechanical Engineering	on	Biswanath Bar			
649	11/ME/112	20110484	Bachelor of Technology in	Mechanical Engineering	on	Sivanto Dutta			
650	11/ME/82	20110333	Bachelor of Technology in	Mechanical Engineering	on	Plaban Roy			
651	17MM8021	17U10406	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Prince Kumar			
652	18MM8001	18U10045	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Lokesh Singh			
653	18MM8002	18U10064	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Khansa Shahnawaz			
654	18MM8003	18U10109	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Anand Yadav			
655	18MM8004	18U10122	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Soumen Basak			
656	18MM8005	18U10136	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Subham Kumar Agarwal			
657	18MM8006	18U10175	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Aman Pr Nonia			
658	18MM8008	18U10216	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Pallavi Ranjan			
659	18MM8009	18U10224	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sarbojit Majumder			
660	18MM8010	18U10229	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Prasun Kumar Paul			

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661	18MM8011	18U10266	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Bhupesh Yadav			
662	18MM8012	18U10271	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Lakshmi Nagarjuna Malla			
663	18MM8013	18U10273	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Atish Das			
664	18MM8014	18U10285	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Preetam Raj			
665	18MM8015	18U10290	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Siddhant Shikhar Gupta			
666	18MM8016	18U10293	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Santosh Hembram			
667	18MM8017	18U10299	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Shivendra Pratap Singh			
668	18MM8018	18U10304	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Durgesh Kumar Jha			
669	18MM8019	18U10311	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Syed Abdur Rahman			
670	18MM8020	18U10346	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Tapojyoti Mohanta			
671	18MM8021	18U10355	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Choppari Srileela			
672	18MM8022	18U10374	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Unmesh Roy			
673	18MM8023	18U10375	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Andugula Ashish Babu			
674	18MM8024	18U10392	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Rabin Mondal			
675	18MM8025	18U10403	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Namrata Majumdar			
676	18MM8026	18U10420	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kailash Thalore			
677	18MM8027	18U10432	Bachelor of Technology in	Metallurgical and Materials Engineering	on	P Sravan			
678	18MM8028	18U10440	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Jissnu Kundu			
679	18MM8029	18U10444	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Karan Kumar Singh			
680	18MM8030	18U10462	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Samareddy Sailaja			
681	18MM8031	18U10468	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kanneti Eswar Reddy			
682	18MM8032	18U10495	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Malobika Biswas			
683	18MM8033	18U10499	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Debakshi Gupta			

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684	18MM8034	18U10500	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Trishikha Saha			
685	18MM8035	18U10510	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Konathala S M Aeyshovardhan			
686	18MM8036	18U10540	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Pullagura Manoj Kumar			
687	18MM8037	18U10551	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sonu Kumar Mishra			
688	18MM8038	18U10565	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kalali Lingam Goud			
689	18MM8039	18U10566	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Karam Krishna Chaithanya			
690	18MM8040	18U10573	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Ankit Adak			
691	18MM8041	18U10574	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Md Shayeeque Alam			
692	18MM8042	18U10577	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Arpan Ghosh			
693	18MM8043	18U10578	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Rohit Kumar Gangopadhyay			
694	18MM8045	18U10594	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Niharika			
695	18MM8046	18U10599	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sharbashis Das			
696	18MM8047	18U10629	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sarathi Dey			
697	18MM8048	18U10652	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Karri Kodhanda Dhanunjay Pavan			
698	18MM8049	18U10680	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Renuka Nag			
699	18MM8050	18U10685	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Aman Verma			
700	18MM8051	18U10691	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Malla Rohith			
701	18MM8052	18U10697	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Nitesh Saini			
702	18MM8053	18U10700	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Ajit Kumar			
703	18MM8054	18U10704	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Jagadish Mahata			
704	18MM8055	18U10707	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Atharva Vilas Vyawahare			
705	18MM8056	18U10719	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Sunil Kumar			
706	18MM8057	18U10726	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Gompa Kiran Kumar			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
707	18MM8058	18U10729	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Kasimalla Prathyusha			
708	18MM8059	18U10736	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Gajraj Gurjar			
709	18MM8060	18U10739	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Rinku Hembrom			
710	18MM8061	18U10767	Bachelor of Technology in	Metallurgical and Materials Engineering	on	Snigdha Chakraborty			
711	17BT1002	17U10227	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Jai Inder Veer Singh Kang			
712	17BT1004	17U10572	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Tiasha Ghosh			
713	17BT1005	17U10577	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Rudranil Das			
714	17BT1006	17U10635	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Abhishek Mishra			
715	17BT1007	17U10741	Bachelor of Technology (under Dual Degree program)	Biotechnology	on	Vikash Kumar			
716	17CH1002	17U10638	Bachelor of Technology (under Dual Degree program)	Chemical Engineering	on	Sudeshna Gun			
717	17CH1003	17U10643	Bachelor of Technology (under Dual Degree program)	Chemical Engineering	on	Vineet Kumar			
718	17CH1004	17U10673	Bachelor of Technology (under Dual Degree program)	Chemical Engineering	on	Gulshan Kumar			
719	17BT1002	17U10227	Master of Technology (under Dual Degree program) in	Biotechnology	on	Jai Inder Veer Singh Kang			
720	17BT1004	17U10572	Master of Technology (under Dual Degree program) in	Biotechnology	on	Tiasha Ghosh			
721	17BT1005	17U10577	Master of Technology (under Dual Degree program) in	Biotechnology	on	Rudranil Das			
722	17BT1006	17U10635	Master of Technology (under Dual Degree program) in	Biotechnology	on	Abhishek Mishra			
723	17BT1007	17U10741	Master of Technology (under Dual Degree program) in	Biotechnology	on	Vikash Kumar			
724	17CH1002	17U10638	Master of Technology (under Dual Degree program) in	Chemical Engineering	on	Sudeshna Gun			
725	17CH1003	17U10643	Master of Technology (under Dual Degree program) in	Chemical Engineering	on	Vineet Kumar			
726	17CH1004	17U10673	Master of Technology (under Dual Degree program) in	Chemical Engineering	on	Gulshan Kumar			
727	17CY1002	17U10308	Integrated Master of Science in	Chemistry	on	Subhradeep Barman			
728	17CY1003	17U10611	Integrated Master of Science in	Chemistry	on	Agniva Mukherjee			
729	17CY1004	17U10636	Integrated Master of Science in	Chemistry	on	Ratan Singh			

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Sl No	Roll No	Reg. No.	Programme	Department		Name	Date of the Ceremony	Photograph	Remarks
730	17CY1006	17U10681	Integrated Master of Science in	Chemistry	on	Mayank Meena			
731	17CY1008	17U10689	Integrated Master of Science in	Chemistry	on	Manoj Singh			
732	17CY1009	17U10712	Integrated Master of Science in	Chemistry	on	Ritam Swarnakar			
733	17CY1010	17U10720	Integrated Master of Science in	Chemistry	on	Piyush Tiwari			
734	17CY1013	17U10760	Integrated Master of Science in	Chemistry	on	Saurabh Kumar			

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Annexure - I
UGAC and PGAC (29/07/2022)

18TH CONVOCATION
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LIST OF POST GRADUATE DEGREE RECIPIENTS

Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of............)	on	Date of Ceremony
1	20BT4101	20P10045	Master of Technology	in Biotechnology	(Department of Biotechnology)	Shreyayukta Chakraborty	
2	20BT4102	20P10053	Master of Technology	in Biotechnology	(Department of Biotechnology)	Abhineet Banerjee	
3	20BT4103	20P10112	Master of Technology	in Biotechnology	(Department of Biotechnology)	Shalini Das	
4	20BT4104	20P10187	Master of Technology	in Biotechnology	(Department of Biotechnology)	Shatakshi Bhattacherjee	
5	20BT4105	20P10224	Master of Technology	in Biotechnology	(Department of Biotechnology)	Nivruthi Sasi	
6	20BT4106	20P10247	Master of Technology	in Biotechnology	(Department of Biotechnology)	Monojit Kamilya	
7	20BT4107	20P10271	Master of Technology	in Biotechnology	(Department of Biotechnology)	Roshan Jaiswal	
8	20BT4108	20P10325	Master of Technology	in Biotechnology	(Department of Biotechnology)	Ashwini Ramdas Santape	
9	20BT4109	20P10345	Master of Technology	in Biotechnology	(Department of Biotechnology)	Kanmani M	
10	20BT4110	20P10389	Master of Technology	in Biotechnology	(Department of Biotechnology)	Kheerthana R	
11	20CE4101	20P10029	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Kundan Kumar Mandal	
12	20CE4102	20P10038	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Nirabhra Agrawal	
13	20CE4103	20P10078	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Sourabh Shrivastava	
14	20CE4104	20P10091	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Niladri Biswas	
15	20CE4105	20P10106	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Umesh Gupta	
16	20CE4106	20P10107	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Bajrabahu Dhananjay Narayan Deo	
17	20CE4107	20P10156	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Sudarshan Barve	
18	20CE4108	20P10159	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Vikash Kumar Pandey	
19	20CE4109	20P10161	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Loka Venkata Krishna Reddy	
20	20CE4110	20P10174	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Nikesh Sharma	
21	20CE4111	20P10175	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Mohammed Mumtaj	
22	20CE4112	20P10177	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Mohammad Yasir Mohammad Hasan Shaikh	
23	20CE4113	20P10189	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Manoranjan Roy	
24	20CE4114	20P10334	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Jalla Sandeep Kumar Reddy	
25	20CE4115	20P10346	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Maroju Ranjith Teja	
26	20CE4116	20P10351	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Gautam Kumar	
27	20CE4117	20P10413	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Mukul Raj Abhishek	
28	20CE4119	20P10456	Master of Technology	in Structural Engineering	(Department of Civil Engineering)	Rohit Kumar	
29	20CE4201	20P10054	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Soumen Purkayastha	
30	20CE4202	20P10072	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Anindya Sundar	
31	20CE4203	20P10077	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Ashish Kumar	
32	20CE4204	20P10083	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Abdul Waris	
33	20CE4205	20P10088	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Kumar Saurabh	
34	20CE4206	20P10090	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Rishabh Kumar	
35	20CE4207	20P10141	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Sanjay Kumar	
36	20CE4208	20P10149	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Sourav Bhattacharjee	
37	20CE4209	20P10178	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Rahul Raman	
38	20CE4210	20P10194	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Gyajangi Harikrishna	
39	20CE4211	20P10200	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Souvik Mondal	
40	20CE4213	20P10257	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Viveka Nand	
41	20CE4214	20P10293	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Devireddy Venu Gopal Reddy	
42	20CE4215	20P10299	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Rajesh Nandi	
43	20CE4216	20P10314	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Vikash Kumar	
44	20CE4217	20P10342	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Shivam Dhar Dwivedi	
45	20CE4218	20P10356	Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	Anupa Chakraborty	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
46	20CH4102	20P10436	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Anekella Sreelekha Reddy	
47	20CH4103	20P10438	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Saira Mohanty	
48	20CH4104	20P10439	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Ekambara Samal	
49	20CH4105	20P10440	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Abhishek Roy	
50	20CH4106	20P10443	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Debasish Mahato	
51	20CH4107	20P10445	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Payal Das	
52	20CH4108	20P10446	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Shubham Kumar	
53	20CH4109	20P10448	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Swasti Ghosh	
54	20CH4110	20P10449	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Arghya Singha Mahapatra	
55	20CH4111	20P10451	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Deepu Kumar Jha	
56	20CH4112	20P10452	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Nikitha Lohia	
57	20CH4113	20P10455	Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	Nilotpal Bora	
58	20CS4101	20P10030	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Jaya Krishna Bhonagiri	
59	20CS4102	20P10036	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Satyabrata Jena	
60	20CS4103	20P10037	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Arghya Bandyopadhyay	
61	20CS4104	20P10042	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Akanksha	
62	20CS4105	20P10056	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Saikumar Poosala	
63	20CS4106	20P10058	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Priyanka Gautam	
64	20CS4107	20P10067	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Abhijeet Kumar	
65	20CS4108	20P10070	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nishkarsh Patel	
66	20CS4109	20P10081	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Subrata Maity	
67	20CS4110	20P10082	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Abhijit Saha	

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68	20CS4111	20P10089	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Debasish Kalita	
69	20CS4112	20P10094	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shailabh Suman	
70	20CS4113	20P10096	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Alka Rani	
71	20CS4115	20P10116	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Oneil Michael Mascarenhas	
72	20CS4116	20P10117	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Saloni Vashisth	
73	20CS4117	20P10118	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Karthik S	
74	20CS4118	20P10134	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Pranshu Sharma	
75	20CS4119	20P10136	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shubham Verma	
76	20CS4120	20P10137	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Salini Kashyap	
77	20CS4121	20P10138	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Saurabh Kumar Jaiswal	
78	20CS4122	20P10142	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aman Kumar	
79	20CS4123	20P10145	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Manoj Kumar	
80	20CS4124	20P10162	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Jayant Kumar	
81	20CS4125	20P10166	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Birju Shaw	
82	20CS4127	20P10180	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Prashant Dubey	
83	20CS4130	20P10190	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Palzang Norgay Bhutia	
84	20CS4131	20P10197	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Pragati Ghansham Dumre	
85	20CS4132	20P10198	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Surya Ravi Sable	
86	20CS4133	20P10215	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Arnab Chatterjee	
87	20CS4134	20P10221	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Priyanka Bansal	
88	20CS4136	20P10229	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Bidyut Bikash Goswami	
89	20CS4137	20P10230	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Yash Makwana	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
90	20CS4138	20P10231	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Ankita Das	
91	20CS4139	20P10238	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Debashish Naik	
92	20CS4141	20P10248	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nirmal Sonal	
93	20CS4142	20P10254	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Anisha Mehnaaz Mallick	
94	20CS4143	20P10256	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aditya Kumar	
95	20CS4145	20P10270	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Bikash Basfore	
96	20CS4146	20P10274	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Anurag Dutt	
97	20CS4147	20P10287	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Roshan Kumar	
98	20CS4148	20P10288	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Amareshwar Chakravarti	
99	20CS4149	20P10289	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Rudra Narayan Mondal	
100	20CS4150	20P10297	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Vijaya Laxmi Yadav	
101	20CS4151	20P10298	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Himanshu Sirohi	
102	20CS4152	20P10303	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Md Faizan Reza	
103	20CS4153	20P10320	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aditya Mohata	
104	20CS4154	20P10323	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Ankita Kumari	
105	20CS4155	20P10326	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Apurva Verma	
106	20CS4156	20P10327	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Kailash Jamuda	
107	20CS4157	20P10329	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Md Aadil	
108	20CS4158	20P10331	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Bandana Sahu	
109	20CS4159	20P10332	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shekhar Chauhan	
110	20CS4161	20P10337	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Rohan Bhagat	
111	20CS4162	20P10357	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Krishna Murti	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
112	20CS4163	20P10361	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Subhojoy Dey	
113	20CS4164	20P10368	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Priyoshma Sonkar	
114	20CS4165	20P10371	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Utkarsh Shukla	
115	20CS4166	20P10372	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Namrata Khadanga	
116	20CS4167	20P10380	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Madhu Kumari	
117	20CS4168	20P10383	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Vinay Kumar	
118	20CS4169	20P10387	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Sudipta Kumar Nath	
119	20CS4170	20P10392	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nandkishore Prakashrao Nangre	
120	20CS4173	20P10402	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Nirmal Kumar Majhi	
121	20CS4174	20P10410	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Vikash Kumar	
122	20CS4175	20P10418	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Sayantan Mukherjee	
123	20CS4176	20P10421	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Aishwarya Manishi	
124	20CS4177	20P10432	Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	Shivang Agarwal	
125	20EC4101	20P10050	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Ranjeet Kishore Bal	
126	20EC4102	20P10061	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Samyat Sahu	
127	20EC4103	20P10075	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Jai Sharan Shukla	
128	20EC4104	20P10100	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Shruti Mary Mathew	
129	20EC4105	20P10129	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Anil Kumar Padhy	
130	20EC4106	20P10155	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Sk Riaz Bin Rafique	
131	20EC4107	20P10160	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Hritwika Sarkar	
132	20EC4108	20P10184	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Neha Pallavi	
133	20EC4109	20P10214	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Jagannath Kundu	

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Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
134	20EC4110	20P10251	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Akhil Kumar Kv	
135	20EC4111	20P10291	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Moumita Mondal	
136	20EC4112	20P10308	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Rishika Kar	
137	20EC4113	20P10353	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Ajay Kumar	
138	20EC4115	20P10370	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Nishat Fatma	
139	20EC4116	20P10382	Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication Engineering)	Sravani Kalakonda	
140	19EC4201	19P10001	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Varsha Kumari Saw	
141	20EC4201	20P10040	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Suraj Singh Rajput	
142	20EC4202	20P10052	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Bhagyashree Trilokdas Goje	
143	20EC4203	20P10104	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Debabrata Sahu	
144	20EC4204	20P10123	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Pavan Suresh Ambhore	
145	20EC4205	20P10125	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Jeevan Tulashiram Thakare	
146	20EC4206	20P10128	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Pallav Punit Chawda	
147	20EC4207	20P10146	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Deepak Kumar	
148	20EC4209	20P10168	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Shubham Kumar Satpute	
149	20EC4210	20P10192	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Ankita Motiram Bat	
150	20EC4211	20P10207	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Laukik Mohan Chavan	
151	20EC4212	20P10217	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Mayank Kumar Tarai	
152	20EC4213	20P10232	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Bishnudev Ojha	
153	20EC4214	20P10258	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Kavita Ghanshyam Saroj	
154	20EC4215	20P10338	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Yogesh Prasad Dewangan	
155	20EC4216	20P10341	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Chandra Shekhar Singh	

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156	20EC4217	20P10349	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Sudhanshu Vinayak Gulavani	
157	20EC4218	20P10359	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Nandita Prodyot Nandi	
158	20EC4219	20P10425	Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication Engineering)	Janhavi Avinash Sane	
159	20EE4101	20P10064	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Sabarna Das	
160	20EE4103	20P10095	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Rachana Rajamma Kaki	
161	20EE4104	20P10103	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Mylagani Manicharan	
162	20EE4106	20P10151	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Rajesh Verma	
163	20EE4107	20P10157	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Rohan Mukherjee	
164	20EE4109	20P10171	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Arindam Chowdhury	
165	20EE4110	20P10202	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Nidhi R	
166	20EE4112	20P10228	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Arpan Naskar	
167	20EE4113	20P10275	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Bikash Kumar Parida	
168	20EE4115	20P10340	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Sayantan Chatterjee	
169	20EE4116	20P10355	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Vishvajeet Tiwari	
170	20EE4118	20P10395	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Neha Kumari	
171	20EE4119	20P10406	Master of Technology	in Power Systems	(Department of Electrical Engineering)	Satyajeet	
172	19EE4201	19P10006	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Ankita Vishwakarma	
173	19EE4203	19P10052	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Priya Malhotra	
174	19EE4211	19P10254	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Jayashree Biswas	
175	20EE4201	20P10031	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Navneet Maddhesiya	
176	20EE4202	20P10033	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Abhishek Rohit	
177	20EE4204	20P10071	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Suman Karmakar	

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178	20EE4205	20P10098	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Akhilesh Bharti	
179	20EE4206	20P10109	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Subhajit Das	
180	20EE4208	20P10167	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Rishabh Raj	
181	20EE4209	20P10173	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Aditya Prakash	
182	20EE4210	20P10176	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Sumit Saha	
183	20EE4211	20P10196	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Sivanatha Reddy Nandyala	
184	20EE4212	20P10273	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Vikas Pandey	
185	20EE4213	20P10290	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Sourav Kumar Sahoo	
186	20EE4214	20P10294	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Abhishek Maji	
187	20EE4215	20P10295	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Bikram Ram	
188	20EE4216	20P10347	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Kalyani Mamidi	
189	20EE4217	20P10348	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Bhanu Prakash Goddugorla	
190	20EE4218	20P10360	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Badal Pandit	
191	20EE4219	20P10394	Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	Jaya Ram Pilla	
192	20ES4101	20P10051	Master of Technology	in Environmental Science and Technology		Dewashish	
193	20ES4102	20P10066	Master of Technology	in Environmental Science and Technology		Yerramshetti Nikhil Sagar	
194	20ES4103	20P10147	Master of Technology	in Environmental Science and Technology		Sandeep Kumar	
195	20ES4104	20P10148	Master of Technology	in Environmental Science and Technology		Adhirath Kumar	
196	20ES4105	20P10172	Master of Technology	in Environmental Science and Technology		Susant Kumar Sahoo	
197	20ES4106	20P10213	Master of Technology	in Environmental Science and Technology		Anamika Tiwari	
198	20ES4107	20P10262	Master of Technology	in Environmental Science and Technology		Nisha Kumari	
199	20ES4108	20P10267	Master of Technology	in Environmental Science and Technology		Santosh Kumar	
200	20ES4109	20P10269	Master of Technology	in Environmental Science and Technology		Rahul Jha	
201	20ES4110	20P10277	Master of Technology	in Environmental Science and Technology		Nagendra Kumar Jilagam	
202	20ES4111	20P10278	Master of Technology	in Environmental Science and Technology		Vinod Kumar Saket	
203	20ES4112	20P10282	Master of Technology	in Environmental Science and Technology		Shardul Srivastava	
204	20ES4113	20P10309	Master of Technology	in Environmental Science and Technology		Kurupati Lokesh	
205	20ES4114	20P10336	Master of Technology	in Environmental Science and Technology		Debasmita Datta	
206	20ES4115	20P10376	Master of Technology	in Environmental Science and Technology		Swapnanil Saha	
207	20ES4116	20P10390	Master of Technology	in Environmental Science and Technology		Shivam Jaiswal	
208	20ES4118	20P10422	Master of Technology	in Environmental Science and Technology		Marrapu Narendra Kumar	

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209	20MA4101	20P10043	Master of Technology	in Operations Research	(Department of Mathematics)	Vickey Kumar	
210	20MA4102	20P10048	Master of Technology	in Operations Research	(Department of Mathematics)	Likhil Dondapaty	
211	20MA4103	20P10073	Master of Technology	in Operations Research	(Department of Mathematics)	Manikanta Narayanasetti	
212	20MA4104	20P10074	Master of Technology	in Operations Research	(Department of Mathematics)	Biswanath Singha	
213	20MA4105	20P10086	Master of Technology	in Operations Research	(Department of Mathematics)	Sanju Kushwaha	
214	20MA4106	20P10101	Master of Technology	in Operations Research	(Department of Mathematics)	Binod Kumar Shaw	
215	20MA4107	20P10218	Master of Technology	in Operations Research	(Department of Mathematics)	Alok Kumar Pandey	
216	20MA4109	20P10279	Master of Technology	in Operations Research	(Department of Mathematics)	Sarvesh Kumar Yadav	
217	20MA4110	20P10354	Master of Technology	in Operations Research	(Department of Mathematics)	Pathade Akshay Shivaji	
218	20MA4111	20P10384	Master of Technology	in Operations Research	(Department of Mathematics)	Himanshu Pandey	
219	20MA4112	20P10398	Master of Technology	in Operations Research	(Department of Mathematics)	Km Shivani Sharma	
220	20MA4115	20P10420	Master of Technology	in Operations Research	(Department of Mathematics)	Nikhitha Polkampally	
221	20MA4116	20P10429	Master of Technology	in Operations Research	(Department of Mathematics)	Priya Bharti	
222	20ME4101	20P10034	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Boddepalli Anil Kumar	
223	20ME4102	20P10044	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rajendra Kumar	
224	20ME4103	20P10065	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Sanju Mondal	
225	20ME4104	20P10069	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Gangineni Sandeep	
226	20ME4105	20P10093	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Pritam Sutradhar	
227	20ME4106	20P10099	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Gadigatla Harish	
228	20ME4107	20P10114	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rahul Kumar Singh	
229	20ME4108	20P10121	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Atul Patel	
230	20ME4109	20P10185	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Sai Jayaram Boggala	
231	20ME4110	20P10188	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Ponnada Durga Prasad	
232	20ME4111	20P10203	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Shahnawaz Sardar	
233	20ME4112	20P10220	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Ravi Kant Kumar	
234	20ME4113	20P10223	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Manish Kumar Choudhary	
235	20ME4114	20P10236	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Adarsh Shivshankar Tiwari	
236	20ME4116	20P10322	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Adarsh Madhukar	
237	20ME4117	20P10339	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Ganesh Suresh Kadam	

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238	20ME4118	20P10378	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rahul Dewangan	
239	20ME4119	20P10385	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Rohit Kumar	
240	20ME4120	20P10393	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Aadil Ahmad Rather	
241	20ME4121	20P10423	Master of Technology	in Machine Design	(Department of Mechanical Engineering)	Abhishek Bhardwaj	
242	20ME4201	20P10049	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Vikash Kumar	
243	20ME4202	20P10057	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Sanam Karmakar	
244	20ME4203	20P10059	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Nitish Kumar	
245	20ME4204	20P10068	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Satya Subham Dash	
246	20ME4205	20P10079	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Somnath Patra	
247	20ME4206	20P10092	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Ashutosh Kumar	
248	20ME4207	20P10102	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Bikash Mohanty	
249	20ME4209	20P10182	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Sainath Jamalpuri	
250	20ME4210	20P10241	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Ravinder Nath	
251	20ME4211	20P10244	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Ankit Arunrao Shivankar	
252	20ME4212	20P10284	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Manish Kumar	
253	20ME4213	20P10302	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Shwetank Pushkar	
254	20ME4214	20P10315	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Meraj Haider	
255	20ME4215	20P10330	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Sarvesh Kumar Yadav	
256	20ME4217	20P10397	Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	Mrinal Sen Raj	
257	20ME4301	20P10041	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Ayushman Dutta	
258	20ME4302	20P10046	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Nawes Qamar	
259	20ME4303	20P10060	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Neel Srivastava	

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260	20ME4304	20P10113	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Mudhundi Ajay Kumar	
261	20ME4305	20P10152	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Nilanjan Mandal	
262	20ME4306	20P10154	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Md Ishteyaqe Alam	
263	20ME4307	20P10193	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Sai Ganesh Nerusu	
264	20ME4309	20P10252	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Tadiboina Naga Raju	
265	20ME4310	20P10253	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Subhadip Mondal	
266	20ME4312	20P10285	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Rahul Barnwal	
267	20ME4314	20P10328	Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	Rohanbhai Jesingbhai Dodiya	
268	20MM4101	20P10032	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Kunal Das	
269	20MM4102	20P10047	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Bishal Bidyut Buragohain	
270	20MM4103	20P10306	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Himangshu Saikia	
271	20MM4105	20P10396	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Shriya Pandey	
272	20MM4106	20P10441	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Akankshya Rout	
273	20MM4108	20P10444	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Anupam Sharma	
274	20MM4109	20P10447	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Rahul Dhibar	
275	20MM4110	20P10453	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Titindra Nath Paul	
276	20MM4111	20P10454	Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials Engineering)	Parthasarathi Maity	
277	20PH4101	20P10143	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Harshan Bhattacharjee	
278	20PH4102	20P10307	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Noorbasha Bhavani Sai	
279	20PH4103	20P10318	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Vikram Bharti	
280	20PH4105	20P10437	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Himanshu Shekhar	
281	20PH4106	20P10450	Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	Athul Raj. R S	
282	20BT4501	20P20055	Master of Science	in Life Sciences	(Department of Biotechnology)	Mayur Anil Umap	
283	20BT4502	20P20076	Master of Science	in Life Sciences	(Department of Biotechnology)	Sritama Sarkar	
284	20BT4503	20P20087	Master of Science	in Life Sciences	(Department of Biotechnology)	Anshuman Singh	
285	20BT4506	20P20131	Master of Science	in Life Sciences	(Department of Biotechnology)	Samprita Das	
286	20BT4507	20P20132	Master of Science	in Life Sciences	(Department of Biotechnology)	Kunal Das	
287	20BT4508	20P20246	Master of Science	in Life Sciences	(Department of Biotechnology)	J Kamal Atab	

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288	20BT4509	20P20263	Master of Science	in Life Sciences	(Department of Biotechnology)	Neha Maurya	
289	20BT4510	20P20281	Master of Science	in Life Sciences	(Department of Biotechnology)	Ilesa Bose	
290	20BT4511	20P20374	Master of Science	in Life Sciences	(Department of Biotechnology)	Anumita Ghanta	
291	20BT4512	20P20388	Master of Science	in Life Sciences	(Department of Biotechnology)	Sounak Sinha Babu	
292	20BT4513	20P20415	Master of Science	in Life Sciences	(Department of Biotechnology)	Kundali Yadav	
293	20CY4501	20P20062	Master of Science	in Chemistry		Dolly Singh	
294	20CY4502	20P20122	Master of Science	in Chemistry		Olympia Garai	
295	20CY4503	20P20139	Master of Science	in Chemistry		Raisa Rupal	
296	20CY4504	20P20144	Master of Science	in Chemistry		Mandira Ghosh	
297	20CY4506	20P20199	Master of Science	in Chemistry		Soumyanath Roy	
298	20CY4507	20P20201	Master of Science	in Chemistry		Koyel Bhattacharya	
299	20CY4508	20P20209	Master of Science	in Chemistry		Sanjukta Das	
300	20CY4509	20P20225	Master of Science	in Chemistry		Anartya Kundu	
301	20CY4510	20P20233	Master of Science	in Chemistry		Sanju Karmakar	
302	20CY4511	20P20240	Master of Science	in Chemistry		Pooja Kumari	
303	20CY4512	20P20243	Master of Science	in Chemistry		Rupa Sarma	
304	20CY4513	20P20264	Master of Science	in Chemistry		Subham Das	
305	20CY4514	20P20266	Master of Science	in Chemistry		Payel Nandi	
306	20CY4515	20P20283	Master of Science	in Chemistry		Dipannita Ganguly	
307	20CY4516	20P20292	Master of Science	in Chemistry		Dipanwita Rout	
308	20CY4517	20P20301	Master of Science	in Chemistry		Pulak Pradhan	
309	20CY4518	20P20312	Master of Science	in Chemistry		Prithish Banerjee	
310	20CY4519	20P20333	Master of Science	in Chemistry		Aman Kesharwani	
311	20CY4520	20P20350	Master of Science	in Chemistry		Deepak	
312	20CY4521	20P20377	Master of Science	in Chemistry		Priya Patra	
313	20CY4522	20P20379	Master of Science	in Chemistry		Soudip Pandit	
314	20CY4523	20P20409	Master of Science	in Chemistry		Abhishek Mahato	
315	20CY4524	20P20428	Master of Science	in Chemistry		Rituparna Saha	
316	20ES4503	20P20127	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Himanshu Das	
317	20ES4504	20P20150	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sritam Kumar Sahu	
318	20ES4505	20P20163	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Bimalesh Dutta	
319	20ES4506	20P20191	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Damudar Hansdah	
320	20ES4507	20P20204	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Prangyaparimita Sahoo	
321	20ES4508	20P20205	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Ashish Kumar Kalendri	
322	20ES4509	20P20234	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Chinmoyee Borgohain	
323	20ES4511	20P20276	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Abir Banerjee	

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324	20ES4512	20P20296	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sangeeta Koner	
325	20ES4513	20P20304	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Pratikshya Panda	
326	20ES4514	20P20310	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Suvendu Kumar Panda	
327	20ES4515	20P20313	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sanjay Kumar Nayak	
328	20ES4516	20P20321	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Saurav Gogoi	
329	20ES4517	20P20352	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Shashank Shekhar Mahapatra	
330	20ES4518	20P20363	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Aakanksha Sunil Borkar	
331	20ES4519	20P20404	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Sagnik Das	
332	20ES4520	20P20426	Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	Manish Bundela	
333	20MA4501	20P20140	Master of Science	in Mathematics		Apurva Sharma	
334	20MA4503	20P20170	Master of Science	in Mathematics		Sayantan Kundu	
335	20MA4504	20P20206	Master of Science	in Mathematics		Itesh Kumar Singh	
336	20MA4505	20P20208	Master of Science	in Mathematics		Nitish Kumar	
337	20MA4506	20P20211	Master of Science	in Mathematics		Amitesh Ray	
338	20MA4507	20P20212	Master of Science	in Mathematics		Neelanjan Mondal	
339	20MA4508	20P20219	Master of Science	in Mathematics		Amit Patel	
340	20MA4509	20P20222	Master of Science	in Mathematics		Saikat Saha	
341	20MA4510	20P20237	Master of Science	in Mathematics		Soumik Chattopadhyay	
342	20MA4511	20P20239	Master of Science	in Mathematics		Pritam Ray	
343	20MA4512	20P20249	Master of Science	in Mathematics		Jahanvi Singh Rajpoot	
344	20MA4513	20P20255	Master of Science	in Mathematics		Pavan Suthar	
345	20MA4514	20P20259	Master of Science	in Mathematics		Muskan Choudhary	
346	20MA4515	20P20286	Master of Science	in Mathematics		Kajal Kumari	
347	20MA4516	20P20311	Master of Science	in Mathematics		Amrita Dutta	
348	20MA4517	20P20316	Master of Science	in Mathematics		Arpit Kumar	
349	20MA4518	20P20324	Master of Science	in Mathematics		Deepanshu Sharma	
350	20MA4519	20P20358	Master of Science	in Mathematics		Radheshyam Kumar	
351	20MA4520	20P20366	Master of Science	in Mathematics		Gopinath Sahoo	
352	20MA4521	20P20386	Master of Science	in Mathematics		Devendra Kumar	
353	20MA4522	20P20411	Master of Science	in Mathematics		Shashi Kumar Gupta	
354	20PH4501	20P20080	Master of Science	in Physics		Aniruddha Ray	
355	20PH4502	20P20084	Master of Science	in Physics		Saikat Mondal	
356	20PH4503	20P20105	Master of Science	in Physics		Aniket Nag	
357	20PH4507	20P20120	Master of Science	in Physics		Rohit Kumar Pandey	
358	20PH4508	20P20133	Master of Science	in Physics		Md Sohel Mondal	
359	20PH4509	20P20153	Master of Science	in Physics		Sougata Dandapathak	

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360	20PH4510	20P20186	Master of Science	in Physics		Biswajit Dash	
361	20PH4511	20P20195	Master of Science	in Physics		Shahid Raza	
362	20PH4513	20P20235	Master of Science	in Physics		Mainak Barman	
363	20PH4514	20P20268	Master of Science	in Physics		Ankita Das	
364	20PH4515	20P20272	Master of Science	in Physics		Pulakesh Barman	
365	20PH4516	20P20300	Master of Science	in Physics		Anik Biswas	
366	20PH4518	20P20344	Master of Science	in Physics		Manisha Paul	
367	20PH4520	20P20381	Master of Science	in Physics		Satarupa Mandal	
368	20PH4521	20P20424	Master of Science	in Physics		Anushka Yadav	
369	20PH4522	20P20433	Master of Science	in Physics		Debaprasad Nayak	
370	20MB4001	20P40001	Master of Business Administrations	(Specialization: Finance)		Debargha Sengupta	
371	20MB4002	20P40002	Master of Business Administrations	(Specialization: Finance)		Arya Shruti Parashar	
372	20MB4003	20P40003	Master of Business Administrations	(Specialization: Marketing)		Kumar Vivek	
373	20MB4004	20P40004	Master of Business Administrations	(Specialization: Finance)		Sourav Kumar Burman	
374	20MB4005	20P40005	Master of Business Administrations	(Specialization: Systems and Operations Management)		Harsh Maurya	
375	20MB4006	20P40006	Master of Business Administrations	(Specialization: Marketing)		Soumyadip Kundu	
376	20MB4007	20P40007	Master of Business Administrations	(Specialization: Finance)		Sanchita Surbhi	
377	20MB4008	20P40008	Master of Business Administrations	(Specialization: Marketing)		Shameek Shreya Saha	
378	20MB4010	20P40010	Master of Business Administrations	(Specialization: Finance)		Pritam Kumar Singh	
379	20MB4011	20P40011	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Payel Das	
380	20MB4012	20P40012	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Sandeep Kumar	
381	20MB4013	20P40013	Master of Business Administrations	(Specialization: Systems and Operations Management)		Saptarshi Mondal	
382	20MB4014	20P40014	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Ashmita Kumari	
383	20MB4015	20P40015	Master of Business Administrations	(Specialization: Marketing)		Alisha Banerjee	
384	20MB4019	20P40020	Master of Business Administrations	(Specialization: Marketing)		Rahul Kumar	
385	20MB4020	20P40021	Master of Business Administrations	(Specialization: Systems and Operations Management)		Sweta Kumari	
386	20MB4021	20P40022	Master of Business Administrations	(Specialization: Systems and Operations Management)		Divyank Kumar	
387	20MB4022	20P40023	Master of Business Administrations	(Specialization: Finance)		Ranu Priya	
388	20MB4023	20P40024	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Priyam Singh	
389	20MB4024	20P40025	Master of Business Administrations	(Specialization: Finance)		Haridwar Paswan	
390	20MB4025	20P40026	Master of Business Administrations	(Specialization: Systems and Operations Management)		Nidhi Kumari	
391	20MB4026	20P40391	Master of Business Administrations	(Specialization: Marketing)		Manohar Kumar Rai	
392	20MB4027	20P40407	Master of Business Administrations	(Specialization: Systems and Operations Management)		Sneha Dey	
393	20MB4028	20P40412	Master of Business Administrations	(Specialization: Finance)		Mainul Islam	
394	20MB4029	20P40414	Master of Business Administrations	(Specialization: Finance)		Akash Kumar Guha	

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA

18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022
LIST OF POST GRADUATE DEGREE RECIPIENTS

Sl. No.	Roll No.	Registration No.	the degree of	in	(Department of………….)	on	Date of Ceremony
395	20MB4031	20P40417	Master of Business Administrations	(Specialization: Finance)		Srijoni Guha	
396	20MB4032	20P40430	Master of Business Administrations	(Specialization: Finance)		Bhumika Bharti	
397	20MB4033	20P40431	Master of Business Administrations	(Specialization: Finance)		Chowdhury Wasim Akram	
398	20MB4035	20P40435	Master of Business Administrations	(Specialization: Human Resource Management and Organisational Behaviour)		Nandan Sharma	
399	20HS4001	20P20019	Master of Social Work			Srabasti Sen	
400	20HS4003	20P20028	Master of Social Work			Srinivasa Nammalwar K	

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA
18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION : Second Week of September 2022
LIST OF B.TECH INSTITUTE GOLD MEDAL RECIPIENTS

Sl No	Roll No	Reg. No.	Awards	to	in recognition of being First in	in	in the academic session ending	Photograph	Remarks
1	18BT8009	18U10172	Institute Gold Medal	Ahana Sarkar	Bachelor of Technology in	Biotechnology	June 2022		
2	18CE8052	18U10618	Institute Gold Medal	Sayantan Bishnu	Bachelor of Technology in	Civil Engineering	June 2022		
3	18CH8019	18U10270	Institute Gold Medal	Saumyajeet Mukherjee	Bachelor of Technology in	Chemical Engineering	June 2022		
4	18CS8138	18U10514	Institute Gold Medal	Abhishek Gupta	Bachelor of Technology in	Computer Science and Engineering	June 2022		
5	18EC8055	18U10423	Institute Gold Medal	Kondapi V S Krishna Praveen	Bachelor of Technology in	Electronics and Communication	June 2022		
6	18EE8085	18U10200	Institute Gold Medal	Balivada Sree Varsha	Bachelor of Technology in	Electrical Engineering	June 2022		
7	18ME8077	18U10357	Institute Gold Medal	Anubhav	Bachelor of Technology in	Mechanical Engineering	June 2022		
8	18MM8019	18U10311	Institute Gold Medal	Syed Abdur Rahman	Bachelor of Technology in	Metallurgical and Materials	June 2022		

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA
18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION : Second Week of September 2022

LIST OF DUAL DEGREE AND INTEGRATED M.Sc INSTITUTE GOLD MEDAL RECIPIENTS

Sl No	Roll No	Reg. No.	Awards	to	in recognition of being First in	in	in the academic session ending	Photograph	Remarks
1	17BT1004	17U10572	Institute Gold Medal	Tiasha Ghosh	Master of Technology (under Dual Degree program) in	Biotechnology	June 2022		
2	17CH1002	17U10638	Institute Gold Medal	Sudeshna Gun	Master of Technology (under Dual Degree program) in	Chemical Engineering	June 2022		
3	17CY1002	17U10308	Institute Gold Medal	Subhradeep Barman	Integrated Master of Science in	Chemistry	June 2022		

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
INDIA
18TH CONVOCATION
TENTATIVE DATE OF CONVOCATION : Second Week of September 2022
LIST OF B.TECH ENDOWMENT GOLD MEDAL RECIPIENTS

Sl No	Roll No	Reg. No.	hereby awards	to		Photograph	Remarks
1	18BT8009	18U10172	D. V. Sitabai Memorial Gold Medal	Ahana Sarkar	for securing highest CGPA in Bachelor of Technology in the academic session ending in June 2022		
2	18BT8009	18U10172	Parpatidevi Chandumal Memorial Gold Medal	Ahana Sarkar	for scholastic excellence amount girl students in Bachelor of Technology in the academic session ending in June 2022		
3	18MM8019	18U10311	Smt. Tarulata Sinha Memorial Gold Medal	Syed Abdur Rahman	for securing highest CGPA in Bachelor of Technology in Metallurgical and Materials Engineering in the academic session ending in June 2022		

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

INDIA

18TH CONVOCATION

TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022

LIST OF INSTITUTE GOLD MEDAL RECIPIENTS OF POST GRADUATE PROGRAMME

Sl. No.	Regn. No.	Roll No.	Institute Gold Medal	to Name	In recognition of being	in	(Department of……….)	in the academic session ending in June 2022
1	20P10112	20BT4103	Institute Gold Medal	Shalini Das	In recognition of being First in Master of Technology	in Biotechnology	(Department of Biotechnology)	in the academic session ending in June 2022
2	20P10107	20CE4106	Institute Gold Medal	Bajrabahu Dhananjay Narayan Deo	In recognition of being First in Master of Technology	in Structural Engineering	(Department of Civil Engineering)	in the academic session ending in June 2022
3	20P10083	20CE4204	Institute Gold Medal	Abdul Waris	In recognition of being First in Master of Technology	in Geotechnical Engineering	(Department of Civil Engineering)	in the academic session ending in June 2022
4	20P10452	20CH4112	Institute Gold Medal	Nikitha Lohia	In recognition of being First in Master of Technology	in Chemical Engineering	(Department of Chemical Engineering)	in the academic session ending in June 2022
5	20P10089	20CS4111	Institute Gold Medal	Debasish Kalita	In recognition of being First in Master of Technology	in Computer Science and Engineering	(Department of Computer Science and Engineering)	in the academic session ending in June 2022
6	20P10061	20EC4102	Institute Gold Medal	Samyat Sahu	In recognition of being First in Master of Technology	in Telecommunication Engineering	(Department of Electronics and Communication	in the academic session ending in June 2022
7	20P10125	20EC4205	Institute Gold Medal	Jeevan Tulashiram Thakare	In recognition of being First in Master of Technology	in Microelectronics and VLSI	(Department of Electronics and Communication	in the academic session ending in June 2022
8	20P10340	20EE4115	Institute Gold Medal	Sayantan Chatterjee	In recognition of being First in Master of Technology	in Power Systems	(Department of Electrical Engineering)	in the academic session ending in June 2022
9	20P10071	20EE4204	Institute Gold Medal	Suman Karmakar	In recognition of being First in Master of Technology	in Power Electronics and Machine Drives	(Department of Electrical Engineering)	in the academic session ending in June 2022
10	20P10282	20ES4112	Institute Gold Medal	Shardul Srivastava	In recognition of being First in Master of Technology	in Environmental Science and Technology		in the academic session ending in June 2022
11	20P10086	20MA4105	Institute Gold Medal	Sanju Kushwaha	In recognition of being First in Master of Technology	in Operations Research	(Department of Mathematics)	in the academic session ending in June 2022
12	20P10069	20ME4104	Institute Gold Medal	Gangineni Sandeep	In recognition of being First in Master of Technology	in Machine Design	(Department of Mechanical Engineering)	in the academic session ending in June 2022
13	20P10092	20ME4206	Institute Gold Medal	Ashutosh Kumar	In recognition of being First in Master of Technology	in Thermal Engineering	(Department of Mechanical Engineering)	in the academic session ending in June 2022
14	20P10046	20ME4302	Institute Gold Medal	Nawes Qamar	In recognition of being First in Master of Technology	in Fluid Mechanics and Heat Transfer	(Department of Mechanical Engineering)	in the academic session ending in June 2022
15	20P10441	20MM4106	Institute Gold Medal	Akankshya Rout	In recognition of being First in Master of Technology	in Metallurgy and Materials Technology	(Department of Metallurgical and Materials	in the academic session ending in June 2022
16	20P10307	20PH4102	Institute Gold Medal	Noorbasha Bhavani Sai	In recognition of being First in Master of Technology	in Advanced Materials Science and Technology	(Department of Physics)	in the academic session ending in June 2022
17	20P20263	20BT4509	Institute Gold Medal	Neha Maurya	In recognition of being First in Master of Science	in Life Sciences	(Department of Biotechnology)	in the academic session ending in June 2022
18	20P20233	20CY4510	Institute Gold Medal	Sanju Karmakar	In recognition of being First in Master of Science	in Chemistry		in the academic session ending in June 2022
19	20P20276	20ES4511	Institute Gold Medal	Abir Banerjee	In recognition of being First in Master of Science	in Applied Geology and Geoinformatics	(Department of Earth and Environmental Studies)	in the academic session ending in June 2022
20	20P20212	20MA4507	Institute Gold Medal	Neelanjan Mondal	In recognition of being First in Master of Science	in Mathematics		in the academic session ending in June 2022
21	20P20133	20PH4508	Institute Gold Medal	Md Sohel Mondal	In recognition of being First in Master of Science	in Physics		in the academic session ending in June 2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR								
INDIA								
18TH CONVOCATION								
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022								
LIST OF INSTITUTE GOLD MEDAL RECIPIENTS OF POST GRADUATE PROGRAMME								
Sl. No.	Regn. No.	Roll No.	Institute Gold Medal	to Name	In recognition of being	in	(Department of……….)	in the academic session ending in June 2022
22	20P40007	20MB4007	Institute Gold Medal	Sanchita Surbhi	In recognition of being First in Master of Business Administrations			in the academic session ending in June 2022
23	20P20019	20HS4001	Institute Gold Medal	Srabasti Sen	In recognition of being First in Master of Social Work			in the academic session ending in June 2022

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR					
INDIA					
18TH CONVOCATION					
TENTATIVE DATE OF CONVOCATION: 2ND WEEK OF SEPTEMBER 2022					
Endowment Gold Medal Recipient					
PROF. M. S. SINHA MEMORIAL GOLD MEDAL (HIGHEST CGPA IN PHYSICS)					
Sl. NO.	Regn. No.	Roll No.	awards	To	
1	20P20133	20PH4508	Prof. M. S. Sinha Memorial Gold Medal (highest CGPA in Physics)	Md Sohel Mondal	for securing highest CGPA in Master of Science in Physics in the academic session ending in June 2022

A Satyam Roychowdhury initiative

SNU SISTER NIVEDITA UNIVERSITY

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (MoU) is made between

National Institute of Technology Durgapur, West Bengal, INDIA, established under Ministry of Education, Government of INDIA by "The Institutes of Technology Act, 2007" having its office at Durgapur- 713 209, West Bengal, INDIA duly represented by Professor Anupam Basu, Director, hereinafter referred to as NITD, which expression shall, unless excluded by or repugnant to the context, be deemed to include its successors in interest and assigns, being the First Party.

And

Sister Nivedita University, Kolkata, established under Sister Nivedita University Act, 2017, having its office at DG-1/2, New Town, Kolkata-700156, duly represented by Prof. Dhrubajyoti Chattopadhyay, Vice Chancellor, Sister Nivedita University, hereinafter referred to as SNU, which expression shall, unless excluded by or repugnant to the context, be deemed to include its successors in interest and assigns, being the Second Party

NIT and SNU will hereinafter jointly be referred to as Parties and individually as Party.

National Institute of Technology Durgapur and Sister Nivedita University, Kolkata are two leading institutions of higher and technical education and research in the country. To promote academic and research cooperation and the development of NIT and SNU as Centres of excellence of higher and technical education and scientific research, NIT and SNU agree to the following broad terms of cooperation.

1. Both the Parties will support each other's endeavours in delivery of academic programmes and research activities through the following though not limited to:

   (i) Collaboration in Research Activities
   (ii) Exchange of faculty in areas of mutual interest
   (iii) Jointly organize events such as seminars, workshops, conferences and training programmes

   (iv) Any other matter/s as agreed which are not covered above

2. Both Parties acknowledge and understand that all financial arrangements, if any, will be subjected to prior written agreement and availability of funds for each activity/project undertaken.
3. The MoU remains in place for a period of Three (03) years from the date of signing of the agreement and may be renewed for a further period of Three (03) years or such time period as agreed by both the Parties in writing.
4. No Party shall have the right to use the name or logo of the other party without the prior approval of that party in writing.

5. The terms of this MoU may be modified/ amended at any time subject to mutual written agreement. Such modifications/changes shall be effective from the date on which both the parties execute them in writing.
6. The MoU may be terminated by either Party by giving 3 months written notice. In the event of termination, both Parties shall ensure that the interest of students working/projects under this MoU is safe-guarded to the extent possible.

Responsibilities of the Parties

Both Parties mutually agree to identify various areas of interest, and depute faculty/officials as per the requirements with mutual consent. The inviting institution shall extend local hospitality to the deputed person.

Both the Parties shall identify faculty for accomplishing the above laid down objectives. Each Party shall attempt to make such faculty available as and when required.
Both the Parties shall organize regular faculty interactions/meets to promote research interaction and collaboration among their faculty members. These meets may be organized for entire institute or specific to any department or school as per mutual convenience.

Each individual research collaboration shall have separate agreement/terms of contract that addresses issues such as Intellectual Property Right (IPR), funding pattern, disclosure of confidential information etc.

In the event of any dispute or difference arising in the implementation of the MoU, such disputes shall be resolved amicably by mutual discussions by the Director of NITD and Vice Chancellor of SNU. All such decisions shall take into account the status of students working/projects under this arrangement and the interest of such students/ projects shall be guarded as much as possible.

Now, based on the aforementioned promise(s), the Parties put their signatures on this MoU on - -

- -.

…………………………	__________________________
Director	Vice Chancellor,
National Institute of Technology Durgapur	Sister Nivedita University
Mahatma Gandhi Avenue, Durgapur	DG-1/2, New Town, Kolkata-700156
PIN-713209, West Bengal	

WITNESSES

1.____________________________________ 1._________________________________

2.____________________________________ 2._________________________________

Date:

Place:

VILNIUS TECH
Vilniaus Gedimino technikos universitetas

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
उद्योगः पुरुषस्य लक्षणम्

Memorandum of Understanding (MoU)
between
Vilnius Gediminas Technical University, LITHUANIA
AND
National Institute of Technology Durgapur, INDIA

A. Title & Parties

The purpose of this Memorandum of Understanding (MoU) is to establish an affiliation by and between:

National institute of Technology Durgapur (here referred as NITD) is an autonomous institution of the Government of India under Ministry of Human Resource Development, with legal address registered at Durgapur 713 209, West Bengal, India, of the FIRST PART

and

Vilnius Gediminas Technical University (VILNIUS TECH) is a state higher education institution, acting according to the Statute approved by Decree No. XI-2150 of the Seimas of the Republic of Lithuania as of 28 June 2012, located at Sauletekio al. 11, LT-10223 Vilnius, Lithuania (hereafter referred to as VILNIUS TECH), of the OTHER PART,

have agreed to foster a cooperative relationship, for the purpose of establishing a formal connection to support and promote the exchange of faculty and students along with other activities and programs.

B. Preamble

I. Definitions. In accordance with the mutual desire to foster cooperation between NITD and VILNIUS TECH, and in order to explore the potential for collaboration in the areas set out below, the two institutions agree to enter the following MoU.

II. Objectives. Both institutes agree to develop the collaborative activities listed in Article III., Areas of Cooperation, in the academic areas of mutual interest, on the basis of equality and reciprocity.

III. Areas of cooperation. Based on the principles of mutual benefit and agreement, both institutions intend to explore opportunities for collaboration in the priority area of environmental engineering as follows:

(a) Exchange of students between the two institutions at both the undergraduate and post-graduate level for short-term academic visit.

(b) Exchange of faculty and research scholars between the two institutions for the purposes of teaching courses, research collaboration, and other discussions.

(c) Development of joint educational and research activities mutually agreed upon by both institutions.

(d) Benchmarking of processes and academics through meaningful mutual inputs.

(e) Research collaboration in the fields with mutual interest between the faculty and staff members of departments and schools of both institutions, including but not limited to the formation of joint research centers, joint application for research funds, joint implementation of research projects, joint publication of academic papers, and jointly organizing international conferences and seminars on mutually agreed research topics.

(f) Joint supervision for Postgraduate students/ Research Scholars of NITD for internships/ projects/ thesis and vice versa.

IV. Forms of cooperation. NITD and VILNIUS TECH agree that detailed terms and conditions that guide each activity identified above will be separately negotiated and agreed upon by the two institutions by each authorized representative signing the implementing agreement for each activity. These terms shall include a description of proposed activity and financial arrangements.

V. Central Authorities. Each institution shall appoint one member of its teaching/research faculty to coordinate the program on its behalf.

The VILNIUS TECH contact person will be Prof. Dr Edita Baltrenaite-Gediene, Research Institute of Environmental Protection, of Vilnius Gediminas Technical University, Sauletekio al. 11, LT-10223, Lithuania Tel: +37052512131/ +370 687 52299, Email: edita.baltrenaite-gediene@vilniustech.lt

and

The NITD contact person will be Prof. Dr. Susmita Dutta, Professor, Department of Chemical Engg., NIT Durgapur-713209, West Bengal, India. Tel.: +91-9434788120; e-mail: susmita.dutta@che.nitdgp.ac.in

VI. Implementation of Memorandum

(a) Both institutions agree that specific projects and activities shall be developed for the implementation of this Memorandum based on discussions and negotiations between the two institutions. Agreements or contracts shall be signed separately to carry out these projects and activities. However, during the tenure of the MoU or thereafter, both VILNIUS TECH and NITD will be free to take up the similar or same type of work independently and will be free to enter into similar MoU with third parties without disclosing the confidential information of the other party, if any.

(b) *Use of Names.* Beyond promoting the activities supported by the terms and conditions of this MOU among its faculty, staff, and students, neither Party shall use the name of the other in any other form of advertising or publicity without express written permission from the other Party. For instances of name use that exceed the terms of this MOU, each Party must seek permission from the other by submitting a draft of the proposed use at least 60 days in advance of the proposed use to the other Party's representative, designated in "Notices" below.

(c) *Academic Freedom.* VILNIUS TECH is committed to preserving and defending the principles and values of academic freedom for their faculty, staff, and students. If collaborative activities implemented under the auspices of this MOU are deemed by either Party to infringe upon that Party's standards of academic freedom, academic rigor, or academic integrity, that Party may withdraw from this MOU immediately without penalty.

(d) *Non-discrimination.* Eligibility for participation in the collaborative activities developed under the auspices of this MOU will be determined without regard to race, sex, color, religion, sexual orientation, marital status, national origin, age, or beliefs. 'VILNIUS TECH' does not discriminate on the basis of race, color, national origin, ethnic origin, religion, creed, age, physical or mental disability, veteran status, uniformed service, political belief, sex, sexual orientation, gender identity, gender expression, pregnancy, marital status, genetic information, social or economic status, or whether a person is a smoker or nonsmoker, provided that the person complies with 'VILNIUS TECH' policy concerning smoking.

VII. Financial Arrangement

Both institutions agree that all financial arrangements shall be determined on the basis of specific projects and activities and will depend on the availability of funds.

VIII. Protection of Intellectual Property Rights

(a) *Research Ethics and Respect of Pre-existing Intellectual Property Rights.* The Parties to this MOU are committed to ensuring that faculty, staff and students participating in collaborative activities under the auspices of this MOU adhere to all relevant governing regulations and standards of ethics in the conduct of research, use of data, dissemination of results, and disclosures of conflicts of interest. Unless otherwise agreed to in writing by the Parties, each Party will retain ownership of its Intellectual Property that pre-exists the effective date of this MOU or is developed outside the auspices of this MOU. If collaborative activities implemented under the auspices of this activity are deemed by either Party to compromise that Party's standards of ethics in research or infringe on its pre-existing or independently developed intellectual Property, that Party may withdraw from the MOU immediately without penalty.

(b) Ownership of any intellectual property (including but not limited to confidential information, know-how, patents, copyrights, design rights, rights relating to computer software, and any other industrial or intellectual property rights) developed jointly during the course of this Agreement shall be vested in both parties to this MoU, as agreed upon in writing in specific project agreements or implementation plans supporting the activities that result in such jointly developed intellectual property.

IX. Revision & Amendment

This Agreement may be amended or modified by a written agreement signed by the representatives of both institutes.

X. Settlement of Disputes

In the event of a dispute relating to any aspect of academic cooperation, parties named in article V., above, in cooperation with the senior leadership of both institutions as needed, will jointly coordinate a resolution to the dispute, in the spirit of independence, mutual respect, and shared responsibility.

XI. Entry Into Force, Duration and Termination, Renewal Clause

(a) **Entry into force.** This agreement shall come into force after the date of last signature, below.

(b) **Duration and termination.** The Memorandum will remain in effect for five years, or until one party gives the other a written notice of termination one month in advance. Once terminated, neither NITD nor VILNIUS TEC' will be responsible for any losses, financial or otherwise, which the other institutions may suffer. However, NITD and VILNIUS TECH will ensure that the provisions of this Agreement shall continue to apply to all activities in progress until their completion.

(c) **Renewal Clause.** The Agreement shall remain in force for a period of 5 years commencing from date of last signature. Both institutions will review the terms of the Memorandum ninety (90) days before the expiry of the five-year term with a view to negotiating a further agreement on terms acceptable to both. Institutions may extend the term by written agreement signed by both after review.

XII. Concluding Paragraph and signature clause

The individuals signing this MOU on a Party's behalf represent that they have the requisite authority and intent to bind that Party to this MOU. This agreement has been made in the English language in two identical copies, one for each institution.

For and on behalf of
National Institute of Technology Durgapur, India

Signature
Name: Prof. Anupam Basu
Designation: Director

Seal:

Witness
Signature
Name: Prof. Susmita Dutta
Designation: Professor, Dept. of Chemical Engg.

For and on behalf of
Vilnius Gediminas Technical University, Lithuania

Signature
Name: Dr Adas Meškėnas
Designation: Vice-Rector for Strategic Partnership

Seal:

Witness
Signature
Name: Prof. Dr Donatas Čygas
Designation: Dean, Faculty of Environmental Engg.

ANNEXURE 67.9

National Institute of Technology Durgapur

Rules and Regulations

for

Sponsored Research & Consultancy Cell (SRCC)

1.0 PREAMBLE:

A cell is created by the Board of Governors, NIT Durgapur for the purpose of Promotion of sponsored research & consultancy to meet future needs of India through meaningful education, original research of the highest standard and leadership in technological innovation for the industrial growth of the Country. In addition to offering formal Undergraduate and Post-graduate Programs, the Institute actively encourages its faculty to undertake sponsored research and consultancy projects in order to strengthen the research profile of the Institute.

Sponsored research activity of the institute is administered through Sponsored Research and Consultancy Cell (SRCC). The cell looks after the administrative and financial aspects of sponsored research, industrial consultancy, testing and certification. SRCC acts as a facilitating Centre in providing assistance for the faculty members of the institute in communicating with the external sponsors, both national and international, and maintaining the accounts from pre-award to post award stage of the project.

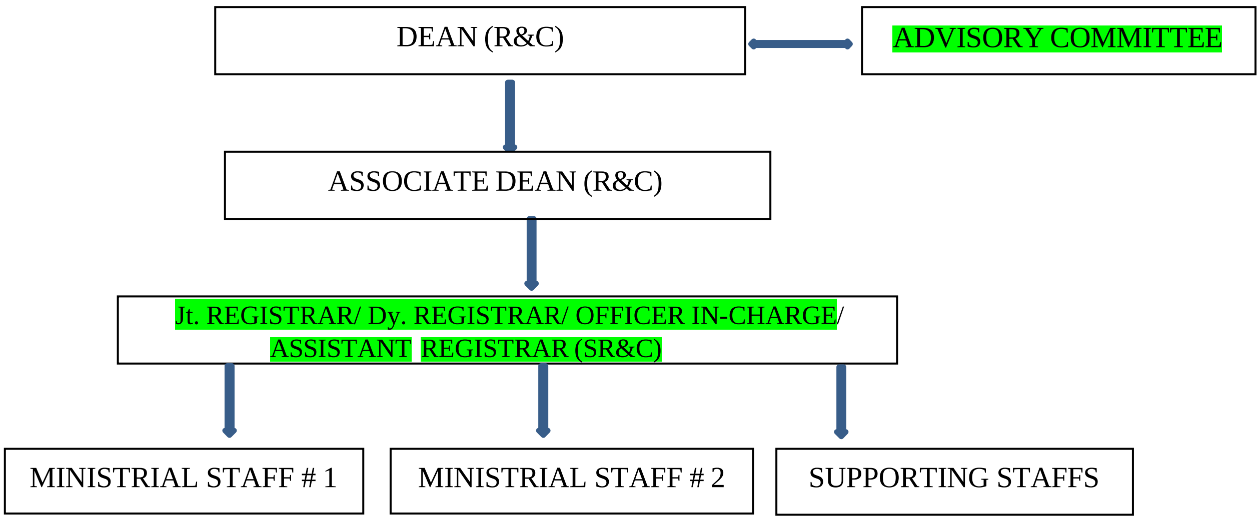
It also promotes and manages Institute-Industry interactions and all externally funded research and development projects as well as patents. All the Industrial Consultancy Projects are to be registered with the SRCC Cell. The Cell acts as a liaison between the Institute and funding agency to undertake sponsored projects.

SRCC shall have total autonomy with respect to the administration of all the sponsored research, industrial consultancy and related matters covered under the SRCC Rules.

SRCC shall be headed by Dean (R&C) and shall consist of Associate Dean (R & C), Assistant Registrar (SR&C) and Ministerial & Supporting staff members and also one advisory committee for guidance. The Dean (R&C) will directly report to Director in all SRCC related issues.

2.0 ORGANIZATIONAL STRUCTURE:

The organizational structure shall be as follows:



ADVISORY COMMITTEE:

The Advisory Committee for SRCC shall consist of following:

(1) Immediate former Dean (R& C)
(2) Dean (Academic Research)
(3) Dean (FW)
(4) Two members nominated by Senate
(5) Two members nominated by Director

3.0 PRINCIPAL INVESTIGATOR (PI):

The term Principal Investigator (PI) refers to a faculty member of the Institute who prepares and submits the project proposal through proper channel and takes full responsibility of carrying out the project to completion along with the achievement of project goals. As a Principal Investigator, one should take into account his professional interest in identifying new and important research questions. One could establish an internal review panel as a team to discuss the efficacy of the proposed study. The team will concentrate on the improvement of scientific content of the proposal. The PI may be assisted by one or more Co-investigators (CI) for achieving the technical goals. The CI(s) will ordinarily be permanent faculty members of the Institute. In case of Inter-institutional projects, the PI of the second institution will be called Co- PI.

PI of a sanctioned project is considered to be the prime interface between the funding agency and SRCC and is operational head of the project. The PI is advised to keep the whole project team aware about the progress of the project and involve the CI(s) in all related project activities. In his/her absence, the PI may request any of the CI to take-over the responsibility of running the project (with or without financial responsibility) and inform the same to SRCC. When the period of leave is likely to exceed one year, the sponsors must be informed by the PI.

PI /Co-PI/CI(s) can claim honorarium in a project only if it is explicitly provided by the Funding Agency.

PI/Co-PI/CI(s) is permitted to go outside the Institute on Special Casual Leave with prior approval of competent authority, for work related to Projects, but without affecting academic activities in the Institute.

The PI shall be responsible for submission of periodical and /or final technical report(s) of the project work as may be required by the sponsoring agency. He / She shall also send a copy of the final technical report to Dean (R&C).

In the consultancy projects, the principal consultant and other consultants will have the same responsibility and authority as of PI and CI of sponsored research projects.

4.0 SPONSORED RESEARCH

4.1 Project Proposal:

All the project proposals to different sponsoring agencies have to be prepared as per the following format or as per the format prescribed by the Sponsoring agency:

Title: The project title shall be a good match to the proposed themes of the funding agency. Moreover, the reviewer should easily remember it.

Summary of the Proposal: One needs to highlight the aims and overview of the research plan. It should demonstrate the importance of the study and generate interest to the reviewer.

Research Statement: PI should incorporate the relevance of the proposed study, the focus of the study and a rational plan to achieve the study goal(s).

Objectives: The proposal should establish the overall direction of the proposed study. In the case of several objectives PI should state the action, the behavior and the standard against which it will be measured.

Literature Review: PI needs to incorporate important work in a concise manner in the proposed study. In addition, PI should try to advance the knowledge.

Study Design: It shall be simple and clear. Moreover, the design should be based on the study objectives. You may need to discuss with the expert in research methods, if necessary, to obtain suggestions on sample design, data measurement, collection and analysis.

IPR issues: The information generated under the projects is usually the joint property of the Funding Agency and the Institute unless otherwise stated in the Contract/Agreement with a funding agency or a collaborative partner with whom the ownership issue is mutually decided beforehand. The same may be protected by means of filing of copyrights/patents etc.

Funding agencies are concerned with ethical issues of the scientific experimentation. PI is responsible for upholding academic integrity and having the requisite clearance from the ethical committee as required.

Budget Estimate:
While making a budget for a project, the following heads should be taken into account:

- Salary of Project Staff (JRF/SRF/Project staff)
- Equipment
- Consumables
- Travel (domestic, international)
- Contingency
- Overheads

In general, for sponsored research projects 20% on the total project cost shall be charged towards service charges (overheads) for utilizing the infrastructural and other facilities of the Institute. The Institute shall support funding for filling patent and fees related to their maintenance.

All research proposals shall be routed through and endorsed by Dean (R&C) on behalf of the Director, with relevant information required by Sponsors. In case of projects requiring significant infrastructure facilities and additional support by the Institute, Dean (R&C) will obtain the prior approval of the Director. The entire outgoing project proposals will be recorded in the proposal register and be filed for documentation of proposals sent to sponsoring agencies for approval.

All sanctioned and approved project proposals have to be registered with the SRCC by filiing up of „Project Registration Form", duly forwarded by HOD/HOC along with a copy of the proposal (both original and recast, if any) and approval by the sponsors for project registration.

It shall be the responsibility of the PI to get the project work completed satisfactorily within the sanctioned grant and duration.

4.2 Project Staff Recruitment:

All the project employees (JRF/SRF/RA/Project staff) will be appointed through open advertisement followed by the interviews. SRCC provides following options of recruiting project staff to kick-start the project activities:

Casual Appointments:
The PI may apply to the Dean (R & C) to engage the manpower as required on casual basis with suitable qualifications starting from the date of their choice. However, such awards are restricted to 89 days only for each individual. These may be given against sanctioned positions. In the meantime, the process for project appointments against the sanctioned posts in the project can be initiated

Project Appointments:
These appointments are purely contractual and renewed every year maximum up to the duration of the project. On receipt of the project, the PI shall forward the request for such engagements to SRCC. SRCC will post the advertisement on Institute website and SRCC notice board. Usually there should be a time gap of about 3 weeks between the advertisement and the last date for receiving the completed application. After the due date the PI will scrutinize the applications received, short list the candidates and get it approved by Dean (R&C). The usual

time gap between the dispatch of call letter and the date of interview should be about 3 weeks but can be reduced if all short listed candidates can be contacted effectively. The project appointees will have to sign an undertaking.

The PI has two options for holding these selections:

Option I - Walk in test/ Interview; and

Option II - Short listing followed by test and / or Interview.

Selection of JRF/ SRF/ RA shall normally be made as per the guidelines provided by the sponsoring agency and with the approval of the Dean (R&C).

Automatic transfer from one project to another either on completion or midway shall not be permitted, except with specific permission from Dean (R&C)/Director.

The PIs shall consider prevailing compensation package, general qualifications and experience for staff while preparing project proposal.

Selection Committee:

The Selection Committee for the recruitment of project staff for each project shall consist of following:

i)	HOD/HOC of the concerned Dept./ Centre to which the PI belongs	- Chairperson
ii)	One faculty member of the PI‟s Dept.	- Member
iii)	One subject expert from outside the Institute as recommended by PI	- Member
iv)	Principal Investigator/Co-Investigator	- Convener

Scheduled selection committees cannot be cancelled at short notice in order to avoid inconvenience to appearing candidates especially coming from outside. The selection process may be conducted offline/online. All appointment letters shall be issued by Dean (R&C) on recommendation of selection committee.

Assistantships/Fellowship:

As per the project guidelines.

Appointing Visiting Scientists:

As per project approval/guidelines the PIs can appoint visiting scientists by invitation against a sanctioned post in a project or from specific project head with the prior approval of Director followed by the recommendation of the Dean (R & C).

Conduct Rules:

A project employee shall execute a Contract Agreement with SRCC at the time of joining with the explicit provision that contract may be terminated by either side (Staff or SRCC Office) by giving one month's notice or one month's consolidated compensation in lieu of the notice.

PIs shall be the sanctioning and controlling authority for all types of leaves with respect to contractual project staff. Project employees shall

a) Follow general code of conduct as approved by SRCC.

Maintain secrecy of the research findings/technical information and shall not get involved in unauthorized communication of any official document or information.

Dean (R&C) may, at his discretion, constitute committee(s) to conduct disciplinary proceedings, if necessary against project employees. On the basis of the report suitable disciplinary action may be initiated and punishment will be imposed by the Dean (R&C).

A Project employee working in a sponsored project of the Institute is eligible to register for the M. Tech. / Ph.D. programme of the Institute subject to his / her satisfying the admission qualifications requirements as per institute rules and regulations. However, the remaining tenure of the project at the time of admission should be at least two years accompanied by the declaration of PI that said scholar will be funded by PI/self financed, if additional time required for the completion of the PhD.

The admitted candidate should give an undertaking that he / she will not be automatically eligible for Institute Fellowship.

4.3 Purchase of Equipment / Consumables:

Purchase of equipment/consumables is to be made by the approved Institute purchase procedure/GFR 2017. PI will take care the procurement process while necessary guidance will be provided by SRCC. However, the bill will be processed by SRCC. For all purchases above Rs. 2,50,000 should be made through SRCC purchase committee:

The SRCC purchase committee shall consist of the following:

i)	Dean (R & C)	Chairperson
ii)	Associate Deans (R & C)	Member
iii)	Jt./Dy./Asst. Registrar (F & A)	Member
iv)	Jt./Dy./Asst. Registrar (P & S)	Member
v)	Jt./Dy./Asst. Registrar (SRCC)	Convenor

Additionally, PI shall be a Member to the Purchase Committee for purchases related to his/her projects.

2. After the due date all the quotations will be opened, examined and signed by the SRCC Purchase Committee. Usually, response from at least three parties is needed for a particular purchase. The committee will sign and recommend the comparative statement. Usually, the purchase recommendation should be on the basis of lowest quotation for the given specifications. However, if the purchase committee feels the necessity to recommend a higher bidder on technical grounds, they can do so by documenting a technical justification for rejecting the lowest quotation with the approval of the competent authority.

3. For specialized items or custom made items procured from a reputed manufacturer or its authorized dealer only, a proprietary nature certificate [SF-6] from PI has to be enclosed for purchase with single quotation.

4. The SRCC shall book the fund and arrange for pre-auditing. Only after the purchase requisition has been pre-audited, it will be forwarded to competent authorities for purchase approval.

5. For purchases upto Rs. 5, 00, 00/-, Dean (R&C) will be the approving authority and for purchases above Rs. 5, 00, 000/-, Director will approve the purchase on the recommendation of Dean (R&C).

6. Finally, SRCC will send the approved purchase file and the draft purchase orders to Registrar for signature. SRCC will particularly ensure that items under taxes, freight, insurance, packing and forwarding, bank charges, payment terms and other terms and conditions are entered correctly in the draft purchase order before sending to Registrar for signature.

Purchase of goods directly under rate contract:

Procurement of the goods under rate contract is to be followed as per the guidelines of the Institute

Imported Items:

The overall purchase procedure for all imported items (equipment, spare parts or consumables) regardless of their value will follow almost the same guidelines with the following additional points which should be taken into account:

1. The quotation should clearly mention if the quoted price is inclusive or exclusive of Indian agent's commission.

2. The commission amount (if any) should be deducted while opening LC.

3. The purchase proposal should contain a Not Manufactured in India (NMI), certificate from PI, if applicable.

4. All purchase orders should mention our cargo releasing agent's name and full address. A copy of the purchase order should be sent to cargo releasing agent at the time of placing the order with the firm for necessary action at their end.

In case of urgency, prior approval of the competent authority is required to make any purchase foreign currency through internet/credit card etc. The need of advance, if any, may also be granted as very special case subject to the approval of the Director.

Procedure for obtaining Engineering Services:

Engineering services such as repair and maintenance work on civil and electrical facilities or alteration / refurbishment will ordinarily be carried out by the Institute Maintenance unit following normal tendering process. However, small works (costing less than Rs. 25000/-) may be arranged by PI at the department level with due approval of HOD/HOC. All formalities of the purchase process, however, should be observed.

4.4 Advance payment:

Advance payment to vendor can be done by taking prior approval of competent authority. The PI may draw advance for such payment and adjustment may be made along with the final bill submitted by the vendor/supplier.

PIs shall normally be allowed to draw another advance only after adjusting the previous one taken by them.

4.5 Payment of Bills:

For all purchases kindly make sure that the bills (except petty cash purchase from imprest account) have S. No., Date and TIN/PAN No. of the vendor/supplier.

While making a purchase, make sure not to pay any Excise Duty as the Institute is exempted from paying it.

Do not incur expenses after the sanctioned duration of the project. Request for extension of projects should be made to funding agencies well in advance.

PIs shall arrange to maintain Procurement-cum-purchase Registers and Stock / Asset Register. These shall be verified by Auditors and SRCC office as and when required. It may be noted that all permanent assets which are of non-consumable nature (equipment/accessories, computers, computer peripherals, furniture etc.) acquired from the project have to be entered in the register of the SRCC and the copy of the same should be sent to central stock entry subsequently.

All the materials / equipment received should be inspected, entered in the stock register and the invoices / bills be certified by PI for payment. In case of purchase of equipment which require installation and demonstration, installation certificate should also be enclosed along with the invoices.
Payment will be made by SRCC through wire transfer/ cheque. .

The usual payment terms for imported items are through LC, which can be opened only after receiving the order confirmation and proforma invoice from the firm.

4.6 Travel & Travel Allowance:

The PI, CI(s) and Project staff can visit places for project work outside the Institute as per entitlement, subject to availability of funds under budget head "Travel or TA/DA" of the project. However, sanction of concerned HOD / HOC is required for being away from the Institute.

All travel bookings are required to be made as per Institute norms. PIs can sanction expenses related to booking of travel tickets (including Tatkal) and cancellation of travel tickets. Prior approval of Competent Authority is required only in case of any relaxation including non-Air India travel.

PI and CI(s) may travel abroad from a project only if a specific provision is available for international travel in the project sanction. Prior approval of competent authority should be obtained before visits as per the govt rules and sanction of leave needs to be obtained from respective sanctioning authority. PI can sanction Registration fees for international conferences from research projects.

On recommendations of PIs, contractual project staff and students working in projects may be permitted with approval of the Dean (R&C) to present papers in National / International Conferences within the country with TA, DA and Registration Fee support provided the funds are available under Travel head of the project.

To meet upcoming expenses during travel, an advance may be drawn. However, it may be noted that such advances need to be adjusted within 15 (fifteen) days from the date of completion of journey. Second advance cannot be sanctioned when the previous advance still remains unadjusted.

Research Fellows (JRFs / SRFs/ RAs) and contract project staff are not entitled for advance. However, they may submit claim for reimbursement of contingency expenditure through proper channel.

The Government of India TA & DA rules will be applicable to the PIs and project employees for all sponsored research/ consultancy projects.

4.7 Organising Seminars/Workshops and Inviting Visitors:

The project may require to arrange/organize Seminars/Workshops/Meetings etc. PIs are empowered for staging such events where such provision exists and the expenses are within the approved budget from Funding Agency. In case no specific provision exists in the project, PI may still sanction expenses within a limit of Rs. 15,000/- from the appropriate head.

Visitors from within country:

PIs can invite outside scientist/expert to the Institute under a project for short duration (up to one week) for project related work with expenses limited to their entitlement. Non-Air India travel requires the approval of competent authority.

Visitors from abroad:

PIs like to invite Students/Researchers/Visitors for project activities from abroad will require the approval of competent authority. In some cases, prior approval of MHRD is also required.

4.8 Finance & Accounts:

A separate book of accounts shall be maintained by SRCC for each project. SRCC should provide the UC & SE as and when required by the sponsors. Govt. Audited statement of accounts at the end of each financial year shall be provided, if required by the sponsor.

In the event, any project utilizes Institute's manpower and other supporting facilities beyond office hours, the expenses towards the same shall be charged to the respective project. For this purpose, on the recommendations of the PI and HOD / HOC concerned, the Dean (R&C) may approve suitable honorarium for the supporting staff of the Institute as per norms approved by the Institute from time to time.

Accounts for sponsored projects shall be maintained under five broad budget heads. These are: Salary, Equipment, Consumables, Travel, Contingency and Overheads.

Cash advance shall be drawn in the name of permanent employees only working in the projects. He / she shall normally be allowed to draw another advance only after adjusting the previous one.

All expenditure shall normally be made within the proposed date of completion of the project. Exception may be permitted with the consent of the sanctioning authority.

SRCC shall ensure that the head-wise expenditure does not exceed the budgetary allocation. For effective control, (or as and when required) expenditure details shall be made available to PIs by SRCC.

The PI shall write to the sponsor for timely release of fund with a copy to the Dean (R&C) for follow up. SRCC will provide the un-audited/audited statement of accounts to PIs for forwarding the same to the sanctioning authority.

Day to day Expenses:

PI may draw a permanent imprest advance of Rs. 10,000/- for meeting day-to-day expenses/petty purchase. PI can draw the next advance only after adjustment of the previous one. The adjustment bills have to submit to SRCC by the PI.

5.0 INDUSTRIAL CONSULTANCY

The Institute has expertise in various research areas to provide knowledge and intellectual inputs which are of interest to the industry. It encourages its faculty to undertake consultancy work, which is an important tool in industrial growth of the Country.

In case of a consultancy project, proposal is prepared by the PI based on the requirement of the industry. It should specifically mention primary component. It may also have the funds, normally consultancy fee as the budget for supporting manpower, equipment, travel, contingency and other such costs to execute the consultancy project.

For projects involving only site visits for consultation work and/or personal discussion, charges will be decided at mutually acceptable rate which shall be based on extent and nature of work. Travelling & Daily allowance will be extra as per the Institute norms.

No consultancy, whatsoever, shall be less than Rs.30,000 and no charges for exclusive material testing shall be less than Rs.5,000.

Industrial Consultancy activities in the Institute and corresponding overhead are of following types:

Sl. No.	Type of Consultancy	Rate of overhead (after deduction of Service Tax)
1	Use of no Institute Facilities	25%
2	Use of institute Laboratory facilities	30%

CALCULATION OF CONSULTANCY FEE:

If project cost (prior to overheads) is P; then overheads of N% will be charged on P as per the table, Service Tax will be 14.5% (presently) or whatever is applicable, on (P + N% overheads).

For example, for a project cost of P =100 and 25% overheads, the calculation is as follows:

Project cost = Rs. 100.00

Overhead = Rs. 25.00

Service Tax = (Rs.100.00 + Rs.25.00) x 14.5% = Rs.18.125

Total fees received from client = Rs.100.00 + Rs.25.00 + Rs.18.125

DISTRIBUTION OF CONSULTANCY FUNDS:

The fund for Consultancy work will be operated by SRCC. The expenditure towards contingencies shall not be more than 25% of the consultancy amount. The consultancy projects where outside agencies will be involved through MOU approved by SRCC shall follow the norms of the MOU. The norms for calculation of various percentages for distribution of the total money received from client (excluding service tax in every case) will be as follows:

General Disbursement Rules:

- Consultancy fees = **C**
- Total expenditure on the project = **E**
- Project cost **P = C + E**
- Overhead Charge **O = P X N%**
- Service Tax **S = (P + O) X 14.5%**
- Total fees received from client **T = P + O + S**

*TDS will be deducted as applicable

Amount **C** (after deducting TDS as applicable) will be distributed among the Investigators, technical & supporting staff and office staff (if required). Fees can be distributed only after successful completion of the project certified by the client.

All sanctioned and approved consultancy project proposals have to be registered with the SRCC by filling up of the ”Project Registration Form”, duly forwarded by HOD/HOC (For category 10.2 in SRCC Form 2) along with a copy of the proposal (both original and recast, if any) and approval by the sponsors for project registration.

It shall be the responsibility of the PI to get the consultancy work completed satisfactorily within the sanctioned amount and duration.

All other norms for consultancy projects presently in vogue shall continue to be applicable with Dean (R&C) having total financial and administrative power. Besides, the rules of sponsored research projects mentioned aforesaid are also applicable.

6.1 **Project Initiation:**

Sl. No.	Activity	Responsibility	Estimated time (Max no. of working days)
1	Submission of proposal to SRCC	PI through HOD or HOC	2
2	Scrutiny of overhead as per norm	SRCC Staff / Asst Registrar (SR&C)	1
3	Endorsement of the proposal	Dean (R&C)/Registrar	1
4	Archive soft / hard copy of the proposal	SRCC Staff	1
5	Dispatch of the proposal (hard copy) to the Sponsor	SRCC Staff / PI	1
6	Registration of the project at SRCC after receipt of sanction letter from the sponsor	PI	-
7	Assign the project number	SRCC Staff	2
8	Intimation of bank account number of SRCC to Sponsor	SRCC Staff / PI	1
9	Budget heads created, received funds in various heads noted. Project operational.	SRCC Staff	2
10	Overhead / service tax deducted from project fund	SRCC Staff	2

6.2 Purchase:

Sl. No.	Activity	Responsibility	Estimated time (Max no. of working days)
1	Preparation of bid document & Tendering	PI	-
2	Preparation of comparative statement & purchase order	PI + SRCC Purchase Committee	3
3	Scrutiny of fund availability and purchase procedure & Approval	SRCC Staff / Internal Audit/ Dean (R & C)	3
4	Signing PO	Registrar	-
5	Dispatch of PO to vendor, PI	SRCC Staff	1
6	Receipt of goods	PI	-
7	Inspection / testing / commissioning etc.	PI	7
8	Entry into measurement book	PI	1
9	Submission of bills, Installation & warranty certificates to SRCC	PI	15
10	Scrutiny of bills & Release of payment to vendor	SRCC	1

6.3 Accounts / Reports:

Sl. No.	Activity	Responsibility	Estimated time (Max no. of working days)
1	Submission of progress reports & other deliverables to the sponsor	PI (with a copy to SRCC)	-
2	Audit of funds each FY	SRCC through Auditor	15
3	Submission of UC & Audit report to sponsor	PI	-
4	Payment of service tax to appropriate authority	SRCC Staff	3
5	Submission of Completion Report to sponsor	PI	-
6	Payment of honorarium to investigators (Consultancy projects)	SRCC Staff / Asst. Registrar (SR&C) / Dean (R&C)	3

6.4 Travel:

Sl. No.	Activity	Responsibility	Estimated time (Max no. of working days)
1	Submission of travel application through HOD/PI	Project staff / PI	-
2	Scrutiny for fund availability	SRCC Staff	1
3	Application for advance	PI	-
4	Approval and release of advance	SRCC Staff /Asst. Registrar (SR&C) / Dean (R&C)	3
5	Submission of TA bill	PI	-
6	Processing of TA bill and adjustment	SRCC Staff / Asst. Registrar (SR&C) / Dean (R&C)	3

6.5 Project Staff:

Sl. No.	Activity	Responsibility	Estimated time (Max no. of working days)
1	Request for recruitment as per provision in sanctioned project along with details	PI	-
2	Scrutiny / Approval	SRCC Staff / Asst. Registrar (SR&C) / Dean (R&C)	2
3	Advertisement on website	-	1
4	Submission of Recommendation of the selection committee along with evaluation sheet and application of the selected candidates, issue of Appointment letter	PI	30
5	Agreement of appointment	-	~~2~~
6	Submission of joining report to SRCC	PI through HOD	2
8	Release of assitanceship/fellowship	SRCC Staff / Asst. Registrar (SR&C) / Dean (R&C)	By 2nd of next month

Availability of concerned officials in SRCC office has been presumed in estimating the maximum number of working days required to complete an activity.

All documents will be finally checked and countersigned by PI.

7.0 Disbursement of Overhead Charges for sponsored Research Project etc.:

Normally overhead charges shall be applicable @20% of the total project cost. Sometime, the overhead charge sanctioned by the sponsoring agency is less than 20%. In that case overhead charges will be acceptable as per sponsoring agency norm.

Distribution of the total ~~Institutional~~ Overheads

Sl.No	Distribution Head	Percentage of Total Amount proposed for '~~Institute~~ Overheads' of SRP
1	Institute Research Development Fund	25
2	Departmental (in which PI belongs) Development Fund	20
3	Professional Development Fund (To be made available to Principal Investigator (PI)	30
4	Research Management Fund	25

Definitions:

1. **Institute Research & Development Fund (IRDF)**
   25% (Twenty Five) of the overheads from Sponsored Research Project will be credited to a fund called Institute Research and Development Fund. 10% of the Institute Research and Development Fund will be transferred every year to a Core Fund, which will form the Corpus of the Institute. The usage of IRDF will be coordinated by Dean (R & C) of the Institute with the approval of the Director. It shall be utilized primarily for the Research & overall developmental activities of the institute, as may be decided by a committee of Deans

2. **Departmental Development fund (DDF)**
   20% (Twenty) of the overheads from Sponsored Research Project shall be transferred to the DDF of the concerned academic department(s). The objective of this fund is to provide additional grant to the department for its developmental activities as well as for funding its other activities for which adequate funds are not available from other sources. This fund can also be used for activities like providing seed money for holding conferences / workshops and seminars etc. The budget proposal for utilizing DDF shall be prepared and submitted by the Department to the Director and utilized after obtaining his approval. The account of DDF shall be maintained by accounts section and statement shall be sent to the department(s) at the end of financial year. The department(s) concerned shall submit expenditure bills to the accounts section for processing payment.

3. **Professional Development Fund (PDF)**

   Professional Development Fund (30% of the overheads from Sponsored Research Project) shall be created for individual faculty. The objective of this will be to help individual faculty member in his / her professional development. The account of PDF shall be maintained by SRCC and statement shall be sent to the departments at the end of financial year. The departments concerned may submit expenditure bills to the SRCC for processing payment. PDF shall be utilized by the concerned individual faculty for expenditure under approved heads (research related items). All expenditures are reimbursable only. The PDF amount can be utilized by the individual even when there are no on-going projects in his / her name. Accumulation of PDF is permitted without any upper limit.

4. **Research Management Fund (RMF)**

   There shall be a research management fund (25% of the overheads from Sponsored Research Project) created in the name of PI to upkeep and maintain the lab/instruments/workspace/furniture/AMC/Air conditioning of the lab. The RMF shall be maintained by the account section and statement will be sent to the respective department at the end of the financial year. The PI concerned may submit the expenditure bill to the Accounts Section for processing and payment. The RMF can be availed even after the completion of the project.

7. Department Promotional Account (DPA):

The DPA can be utilized for the Procurement of equipment, consumables etc. for the department. When the PI is associated with more than one department/ centre, the grant for the DPA will be credited to the account of department / centre recommended by PI.

The advisory and monitoring committee as approved by the BOG shall remain in vogue.

SF-01

SPONSORED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY, DURGAPUR

SPONSORED PROJECT REGISTRATION
(To be submitted along with the sanction letter from the sponsoring agency)

1. Title of the research project:
2. Name of the sponsoring agency & address:
3. Sanction letter no. & date:
4. Total grant sanctioned:
5. a) Duration:

   b) Date of commencement of the project:
6. Name of the Department/Centre, where research is to be performed:
7. Name & Designation of the Principal Investigator:
8. Name(s) & Designation of the Co-Principal Investigator(s):

9. Year-wise break-up of grant sanctioned:

Heads of expenditure	1st year (Rs.)	2nd year (Rs.)	3rd year (Rs.)	4th year (Rs.)	Total (Rs.)
Salary / Fellowship					
Equipment					
Consumables					
Contingencies					
Travel					
Service Charges					
Others (please specify)					
Total					

10. Mode of payment of grant in installments, if any:

11. Details of project staff sanctioned:

Name of the Post	Consolidate compensation / fellowship	No. of post

12 Whether necessary expertise and facilities are available withinDepartment/Centre: YES / NO

If no, then state where the additional facilities are available in the Institute

13. Whether the research project proposal was placed before the Departmental Research Committee: Yes /No

Signature of Principal Investigator

Recommended

Signature of the Head of the Department / Centre

Assistant Registrar (SR & C)

Dean (R & C)

SF-1A

SPONSORED RESEARCH & CONSULTANCY CELL
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Articles of Agreement made this___________day of__________Two thousand ________ by and between the Sponsored Research and Consultancy Cell (hereinafter called the SRCC) of ONE PART and Mr./Ms. ____________________ son/daughter of Mr. _________________ residing at __________ hereinafter referred to as the 'Party of the Second Part' of the OTHER PART.

WHEREAS the 'Party of the Second Part' has been appointed by the SRCC on contract basis to serve as__________________________in sponsored research project entitled " __________________" sponsored by ___________________

AND WHEREAS the 'Party of the Second Part' has agreed to serve the said project as ______________________on the specific terms and conditions hereinafter contained as well as general terms and conditions regulated by the SRCC.

NOW THESE PRESENTS WITNESSTH and the Parties hereto agree subject to the general terms and conditions regulated by the SRCC.

1) The 'Party of the Second Part' shall serve the said project as __________________ on a consolidated compensation of Rs. ____________ (Rupees __________ only) per month. No DA and other allowances are admissible.

2) That the 'Party of the Second Part' is joining the said project with full knowledge and understanding that the project is a contract job. The tenure of this assignment is up to one year and this contract will automatically terminate on the afternoon of the same day.

3) The 'Party of the Second Part' shall devote his whole time and attention to the service of the project undertaken by the Principal Investigator (PI) and shall be subject to the Rules and other provisions of the SRCC relating to assignment under contract.

4) The 'Party of the Second Part' may be provided with hostel accommodation, if available, and shall be liable to pay license fee and charges for water, electricity and any other services rendered thereunder.

5) If so required, the ‘Party of the Second Part’ shall have to perform on a staggered or shift duty including six days a week.

6) The Contract Service of the ‘Party of the Second Part’ may during the period of contract, be terminated by the SRCC at any time by one month’s notice given during the period of contract. The contract may be terminated at any time due to non-availability of funds or unforeseen termination of the project by the sponsor. In such eventuality, the SRCC shall pay one month’s compensation to the ‘Party of the Second Part’. The ‘Party of the Second Part’ may terminate his contract service by giving one month’s notice.

7) The ‘Party of the Second Part’ shall be eligible to avail 8 days Casual Leave and 10 days (20 days with one half of full compensation) with full compensation. The ‘Party of the Second Part’ shall be provided with outdoor treatment facilities and medicines normally available at Institute Medical Unit only for self and dependents (spouse & children).

8) The ‘Party of Second Part’ thus appointed with consolidated compensation shall not be eligible for Gratuity and other benefits. No LTC / HTC shall be admissible.

9) In respect of any other matter for which no provision has been made in this agreement the ‘Party of the Second Part’ be governed by the SRCC rules and the administrative orders issued by the Dean (R&C) or by his nominee from time to time.

10) The ‘Party of the Second Part’ further understand that this contractual assignment under SRCC will not give him any right whatsoever for automatic absorption into the Institute’s Cadre.

In witness whereof the ‘Party of the Second Part’ and the Dean (R&C) or his nominees for and on behalf of the sponsoring agency have hereunto set their hands the day and year first above written.

Signed by the party on the Second Part	Signed by the Dean (R & C) or his nominee for and on behalf of the sponsor
Witness:	**Witness:**
1) Signature:	1) Signature:
Name:	Name:
Designation:	Designation:
(Principal Investigator)	
2) Signature:	2) Signature:
Name:	Name:
Designation:	Designation:

SF-02

SPONSRED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

REGISTRATION OF CONSULTANCY PROJECT
(To be submitted with the original request from the client)

DETAILS OF THE CONSULTANCY PROJECT:

1. Title of the Consultancy Project:
2. Name of the Client & Address:
3. Name of the Consultant - in – Charge:
4. Name of the Consultant (s):
5. Name (s) of the Department / Centre (where Research is to be performed):
6. Type of the Client:
7. a) Consultancy Fee: Rs.
   b) Total expenditure on the project: Rs.
   c) Overhead Charge: Rs.
   d) Service Tax (as applicable): Rs.
   e) Gross consultancy Charges (a+b+c+d): Rs.
8. Date of Commencement of work:
9. Date of Completion of work:
10. THE CONSULTANCY PROJECTS INVOLVES (Tick Appropriate one)

10.1 Use of no institute facilities

10.2 Use of institute Laboratory facilities

The above proposal may please be approved.

(Signature of Consultant in-charge)

RECOMMENDATION OF THE HOD / HOC (Only for category 10.2)
This is to recommend that the consultancy project belongs to the category 10.2 and the Consultant (s) would be given necessary facilities including leave provided the consultant(s) make(s) necessary arrangement for the academic loads assigned to them.

Signature of HOD / HOC

Assistant Registrar (SR&C)

APPROVED

DEAN (R&C)

SF-2A

SPONSORED RESEARCH & CONSULTANCY CELL
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

REQUEST FOR SERVICE CONTRACT
(A separate form to be use for each person/agency)

Date:

1. Name of the sponsored project:
2. Project code:
3. Sponsoring agency:
4. Name of the PI and Dept. /Centre:
5. Brief title of job / service to be assigned on contractual basis:

6. Time period for completion (limited to maximum 89 days):

From to (mention dates)

8. Proposed total value of contract:

9. Name of the person/ agency to whom the contractual assignment to be awarded (with a short resume in a separate sheet):

10. a) Whether the person/agency served any contractual assignment in the project / any other project in the past :

b) If yes, the details of the same:

(Please note that service contracts will be approved only in very special cases. Please enclose proper justification of the contract, some details of work to be assigned in phases, and competency of the person/agency to do the service contract)

UNDERTAKING FROM PI:

I hereby certify that the above service contract is essential for the timely completion of the project and that the service providers / agency to be engaged for the work are sufficiently qualified and experienced to carry out the job and that the charges proposed to be paid are reasonable and economical. The expenditure will be met from the contingency grant of the project.

Countersigned by   Principal Investigator

Head of the Dept. /Centre

Availability of fund under contingency head: YES / NO   Approved / Not approved

Assistant Registrar (SR&C)   ____________________

Dean (R&C)

Contract No.   dated,

SF-2B

NATIONAL INSTITUTE OF TECHNOLOG DURGAPUR
SPONSORED RESEARCH & CONSULTANCY CELL
CONSULTANCY / TESTING MONEY RECEIPT ISSUE APPLICATION FORM

Name of Consultancy/Testing in-Charge /P.I.: -

Department: -

Job Ref No.: -

Date: -

Please allow Mr…………………………………………………………………………………………………….

On behalf of M/s & Address ………………………………………………………………………………………

……

with GSTIN NO..……………………………………………………………………………………………….

to deposit an amount as detailed below for the purpose of ……………………………………….………..……..

……

Mode of payment: - Cash / Online transfer / Cheque / Demand Draft.

Details of payment: -

Consultancy / Testing fee (C)		Rs.
Expenditure (E)		Rs.
Institute Overhead (O),@ 30%* / 25% of (C+E)		Rs.
Add CGST@9% of (C+E+O)	OR Add IGST @ 18% of (C+E+O)	Rs.
Add SGST@9% of (C+E+O)		Rs.
Total		Rs.

Project Cost (P) = Consultancy / testing fee(C) + Expenditure(E),
30%* applicable when Institute/department infrastructure/facility is utilized, otherwise 25%.

Rupees…………………………………………………………………………………………

Signature of Consultancy / Testing in-Charge / P.I.

Signature with Stamp

<u>Enclosures: -</u> 1. Registration of Consultancy Project {approved by Dean (R&C)}
2. Fund transfer voucher from funding agency.

NATIONAL INSTITUTE OF TECHNOLOG DURGAPUR
SPONSORED RESEARCH & CONSULTANCY CELL
DISTRIBUTION OF CONSULTANCY / TESTING CHARGE APPLICATION FORM

Distribution and transfer of Consultancy / Testing amount to Dr……………………………………………………..

The undersigned faculty member of the Department of.. have done the consultancy works, the details of works with all relevant documents are attached herewith for your kind perusal. I am further requesting you to credit the mentioned amount to them given below.

Total fees received from client (**T**), **T= P+O+S** = Rs…………………………………………………………………

Where, **E**(Expenditure) Rs…………………………………………………………………………………….........
P= Project cost including Consultancy / Testing fees (**C**) + Expenditure (**E**) =**C+E** Rs……………………………..…
0= Overhead charge of the Institute, 25% or 30% of **'P'** as per norm Rs……………………………….................
S= GST (SGST+CGST or IGST) charge, 18% of **'P+O'** Rs……………………………………………………...

Total Share of PI / PIs / Others (**T-E-O-S**) Rs…………………………………………………………………

Share of PI / PIs / Others: -

1. Name: - ……………………………………………………. Rs……………………………………………..…
2. Name: - ……………………………………………………. Rs……………………………………………..…
3. Name: - ……………………………………………………. Rs………………………………………………
4. Name: - ……………………………………………………. Rs……………………………………………..…
5. Name: - ……………………………………………………. Rs……………………………………………..…

Note:

Self-assessment tax computed incorporating the consultancy income to be paid by the respective PIs / employees as per Income Tax Act in force or to be amended time to time.

Signature of PI/PIs **Forwarded by HoD** **Asstt. Reg. / Dy. Reg. / Jt. Reg.** **Dean (R&C)**

Asstt. Registrar (Internal Audit) **Director**

Enclosures: -**1.** Bank details, **2.** Reg. of Consultancy Project {approved by Dean(R&C)} photocopy, **3.** Consultancy (work) Completion Report **4.** Money Receipt photocopy

SF-03

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
SPONSORED RESEARCH & CONSULTANCY CELL
PROFORMA FOR APPROVAL (Sponsored Project) IN DIFFERENT HEAD IN PROJECT

Name of the PI / Co-PI / Other (s):

Department:

SRCC Project Registration No.:

Project Sanction Order No.:

Head of expenses:

Consumable / Contingency / Equipment to be procured with estimated price, specifications:

Sl. No.	Item	Quantity	Brief specifications	Estimated Price (Rs.)
Total Estimated Price (Rs.)				

Total fund sought: Rs.

For Travel

Sl. no.	Details of Travel	Estimated Price (Rs.)
Total Estimated Price (Rs.)		

Total fund sought: Rs.

[to be printed overleaf]

For Others

Sl. no.	Details	Estimated Price (Rs.)
Total Estimated Price (Rs.)		

Total fund sought: Rs.

<u>It is certified that</u>

1. The Sponsoring Authority has sanctioned the funds to above Consumable / Contingency / equipment / TA / other expense under... head.
2. Fund is available under this head.
3. The approval may now be paid out of **Rs.** ………………………… for the **F.Y. year**………………

Signature of the PI / Co-PI / Other (s)

Signature of HoD

- PI / Co-PI / Other (s) are requested to follow the **GFR – 2017** & basis of the Project as well as the rules of funding Agency.
- During reimbursing the bills please attached this original approval and original bills duly signed & stamp by the PI / Co- PI / other (s).

Superintendent (SRCC) **Joint Registrar (SRCC)** **Dean (Research & Consultancy)**

SF-04

SPONSORED RESEARCH & CONSULTANCY CELL
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FELLOWSHIP / MANPOWER CLAIM

1. Name of the Fellow / Manpower: -

2. Account No: - IFSC Code: -

   Bank & Branch Name: -

3. Designation with Department: -

4. Month for which the claim is: -

5. Amount Claimed: -

6. Source from which the money is received: -

7. Name of the Scheme / Individual: -

8. If the Institute Scholarship was previously drawnbefore joining as Research Fellow: -

9. The period rate and total amount of Institute Scholarship: -

10 The period and amount of Tuition Fees and SeatRent already paid as Institute Scholar: -

It is certified that

Signature of the Claimant
Mob.-

- ○ The Fellow has not availed of any disqualified leave.
- ○ The Fellow has not availed of any leave without Fellowship during the period.
- ○ The sanction of the Sponsoring Authority exists for the payment as mentioned above.
- ○ Fund is available.

Duration of the scheme is .... SRCC Project Registration No. **NITD/SRCC/**

Payment may be arranged from………………………

Signature of PI / Co-PI / PD / Mentor with Seal

FOR SRCC USE ONLY

○ **Checked** **Approved / Not Approved**

Superintendent (SRCC) **Joint Registrar (SRCC)** **Dean (Research & Consultancy)**

SF-05

SPONSORED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Application for Enrolment in the Ph. D. Programme (For use of JRF, SRF, RA employed in a sponsored scheme/project individual scholarship holder of CSIR / UGC)

To

The Dean (Academic Research),

National Institute of Technology, Durgapur

(Through: Proper Channel)

Sir,

I am interested to enroll for the Ph. D. degree of the Institute and request for your permission to join the Research programme in the Department / Centre_____________________________and furnishing the following information and testimonials in support of my application.

1. Name of applicant (in full):

2. Nature of the offer received: (a) Appointment in a tenure scheme / project or (b) Award of individual fellowship

(* Strike out the one not applicable)

3. Joined in the Department / Centre _______________ in the capacity of _________________ on date _______________

4. (a) Tenure of the award_____________Years __________ Months effective from the date

   (b) Name of the Scheme / Project:

5. Home Address:

Pin _________________

6. Academic Qualification:

Standard	Degree	Board / University	Year of Passing	CGPA / % of marks	Subjects offered
XII					
Graduation					
Post Graduation					
PhD					

7. Particulars of all India qualified in (GATE / CSIR / NET) etc.:

Name of the test	Conducting authority	Year of qualifying	Score

8. Accommodation:

(a) Presently staying at ____

(b) Accommodation requesting for in a Hall of Residence______(REQUIRED / NOT REQUIRED)

9. Declaration:

I hereby give the undertaking that on being permitted to enroll in the Ph. D. programme

(i) I shall obtain a certificate of fitness from the SMO, Medical Unit

(ii) Pay all necessary fees & deposits as required by the Institute

(iii) Abide by all conditions prescribed by Regulations and further directives / instructions issued by the authorities from time to time.

Dated ________________ (Signature of the applicant)

For Sponsored Scheme / Projects:

Certified that the particulars furnished above by the applicant have been verified and found to be correct. I have no objection to his/her being enrolled for the Ph. D. degree.

Date__________________ (PRINCIPAL INVESTIGATOR)

The DRPC has interviewed the applicant and found him qualified for enrolment for the ph. D. degree (if admitted) all necessary facilities will be made available to the applicant.

Forwarded and recommended

Date________________ (Signature of the Head of the Department / Centre)

The applicant may be allotted a seat in the_______________________Hall of Residence.

(CHIEF WARDEN)

The candidate is eligible / not eligible for enrolment and therefore may be / may not be admitted.

DEAN (R & C)

ASST. REGISTRAR (SR&C)

ASSOCIATE DEAN (R&C)

** Testimonials to be enclosed:
1. Copies of Certificate and/or mark sheet of
(a) Date of Birth proof (b) Bachelor's degree examination (c) Master's degree examination (d) Migration
2. Copy of qualifying certificate of GATE or NET etc. (as the case may be)

SF-06

PROPRIETORY NATURE CERTIFICATE

1) Certified that articles mentioned in quotation no. ________________________________

Dated __________________________ are proprietary items of M/s

____.

2) M/s ____ is the sole manufacturer / distributors / established importers / dealer of these articles.

3) Certified that the rates quoted by M/s ____ are the same and not higher these quoted with other Government, Public Sector or Private Organization.

Signature

(Name & Designation of the Company

Official signing this certificate with date & seal)

____

(* To be issued on the letterhead of the firm from whom the stores are to be procured)

SF-06

Annexure-V

National Institute Of Technology Durgapur 713209

(An Institute of National Importance under Ministry of Education, Govt of India)

PROPRIETARY ARTICLE CERTIFICATE

Valid for the Current Financial Year

File Number and Date Reference			
1	Description of the article		
2	Forecast of quantity/annual requirement		
3	Approximate estimated value for above quantity		
4	Maker's name and address		
5	Name(s) of authorized dealers/stockists		
6	I approve the above purchase on PAC basis and certify that:-Note- Tick to retain only one out of (b), (c-1) or (c-2) whichever is applicable and cross out others. Please do confirm (a) by ticking it- without which PAC certificate will be invalid.		
6(a)	This is the only firm who is manufacturing/stocking this item. AND		
6(b)	A similar article is not manufactured sold by any other firm, which could be used in lieu OR		
6(c-1)	No other make/brand will be suitable for following tangible reasons (like OEM/warranty spares): OR		
6(c)	No other make/brand will be suitable for following intangible reasons (if PAC was also given in the last procurement cycle, please also bring out efforts made since then to locate more sources): OR		
7	Reference of concurrence of finance wing to the proposal:		
History of purchases of this item for past three years may be given below			
Name of the supplier			
Order/Tender References & Date	Quantity Ordered	Basic Rate on Order (Rs.)	Adverse Performance Reported if Any

Recommended by : Name & Signature of Indenter---

Signature of Approving Authority (HOD/HOC)-------------------------- Stamp & Date

SF-07

SPONSORED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

FORM FOR DRAWAL OF TRAVELLING, DAILY ALLOWANCE & REMUNERATION

1) Name in full:

2) Budget Head:

3) Purpose of Journey

4) Department:

5) Project Sanction Order No:

6) SRCC Registration No:

PARTICULARS OF JOURNEY AND HALTS				Mode of Journey Remarks									
Departure		Arrival		Road			Rail			Air			
Station	Date &Time	Station	Date & Time	Class	Distance (KM)	Fare (Rs.)	Class	Distance (KM)	Fare (Rs.)	Class	Distance (KM)	Fare (Rs.)
					Total			Total			Total	

CERTIFICATION: -

1. Certified that I was / I was not treated as Guest during my halt at .... and was / was not provided with board and lodging / lodging only at State expense / at the expense of the Government of India or another organization (Scheduled tariffs / Hotel bills attached)
2. Certified that this claim is not referred to and paid from any other source.

Signature of the member who travel

Signature of the PI / Co-PI / Other(s) with Seal

P.T.O.

[to be printed overleaf]

Mode of Payment: ☐ **Cheque** (Advance if any) **or** ☐ **RTGS/NEFT (Tick any one)**

Name of Beneficiary:		Bank & Branch Name:	
Beneficiary's A/c No:		IFSC Code:	

PARTICULARS	**AMOUNT (Rs.)**	**For Office Use Only**	
		Admitted Amount(Rs.)	**Pay** Rs…………………(Rupess……………………. ……………………………………..… only)
Road ways fare @ Rs…........./ KM (Institute TA Rule)			
Rail ways fare			
Air ways fare			**Suptd.(SRCC)** **Jt. Reg. (SRCC)**
Hotel Accommodation			
Food Bill			
Remuneration to Expert			**Dealing Asstt. (I. A.)** **Asstt. Reg. (I. A.)**
Actual Expenses			
Less (Advance if any)			
Other Deduction (if any)			**Dean(R&C)** / **Registrar**
NET CLAIM			

(Rupess…………………………………………………………………………
……………………………………………………………………………...…only)

Signature of the PI /
Co-PI / Other(s) with Seal

Signature of HOD with Seal

Received the payment in full (if yes cheque)

Signature of the Claimant Ch. No……………………………….
Date:………………………

SF-08

SPONSORED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

REPORT OF THE ASSESSMENT COMMITTEE FOR EXTENSION / UPGRADATION / ENHANCEMENT OF MONTHLY FELLOWSHIP

(For Research Fellow (SRF / JRF) of CSIR (Individual) / CSIR Scheme / other Research Projects)

NOTE: 1. The Assessment Committee will meet after 2 (two) / 3 (three) / 4 (four) years of continuous research work by a fellow to consider extension / up gradation of fellowship for the 3rd / 4th / 5th year as well as enhancement of monthly fellowship.

2. The fellow is required to submit Annual Progress Report duly supported by publications in the form of reprint / pre- prints / manuscripts of paper accepted or communicated for publication through journal in the field of research work.

The Assessment Committee shall consist of:

1. Prof. -- . . . ... Chairperson

   (Head of the Dept. / Centre)

2. Prof. ____ . . . ... Member

   (Principal Investigator / Supervisor)

3. Prof. ____ . . . . .. Expert

   (From allied Dept. / Centre of this Institute; not below the rank of Associate Professor who is an expert in the relevant field.)

4. Prof. ____ . . . ... Member

   (Second Member as Chairman when PI is HOD / HOC)

Assessment Committee met on:

Name of the Fellow:

If CSIR (Individual Fellow), furnish CSIR Sanction No. with Date

Date of joining:

Date of Registration:

Name of Sponsor:

Area of Research problem assigned:

Title of the Scheme / Project:

RECOMMENDATION OF THE ASSESSMENT COMMITTEE:

* The Committee is satisfied with the progress of his / her work and his / her performance at the interview.

** The Committee feels that the work done so far is not satisfactory.

IT THEREFORE RECOMMENDS THAT

* The Fellow be granted extension / upgradation / enhancement of monthly stipend w. e. f ________________ for __________________________ year

** The fellow be required to continue his / her work with the initial rate of fellowship for a further period of _______ Months, at the end of which he / she will submit a fresh report for consideration of the Committee subject to approval of CSIR / other sponsor.

This recommendation of the Committee, together with a copy of progress report duly supported by publications in the form of re-print / pre-prints /manuscripts of paper accepted or communicated for publication in the Journal submitted by the Research Fellow be forwarded to Associate Dean (SR&C) for onward transmission to CSIR, New Delhi for further action.

SIGNATURE OF THE MEMBERS WITH DATE:

____

(Principal Investigator / Supervisor)

____

(Expert)

____

Chairperson of the Assessment Committee / Second member of

the Committee as Chairperson when PI is HOD / HOC

In view of the recommendation of the Assessment Committee already accepted by the Head of the Dept. / Centre/ Second Member of Committee as its Chairperson, the Fellowship of Mr. / Ms. /Mrs -- is approved.

DEAN (R & C)

Forwarded to:

To

NATIONAL INSTITUTE OF TECHNOLOG DURGAPUR

SPONSORED RESEARCH & CONSULTANCY CELL

TA / DA / TEMPORARY ADVANCE APPLICATION FORM

1) Name (in full) of the PI / Co-PI:

2) Department.:

3) Budget Head:

4) Title of the Project:

5) Project Sanction Order No:

6) SRCC Registration No:

7) Purpose of the advance in details:

8) Place of visit:

9) Purpose of visit:

11) Duration: from ………………………………………………to ………………………………………………

12) Amount of TA / DA / TEMPORARY advance required: Rs.

13) Whether previous advance has been adjusted: **YES / NO**

Declaration by the PI / Co-PI: I have made necessary arrangements for my teaching and other duties during my period of absence as stated above (not necessary for project staff).

Signature of the PI / Co-PI with Seal

<u>Signature of HOD with Seal</u>

Note: Please attach a break-up of estimated expenditures for which the advance is being sought. Advance is granted only to PI / Co-PI.

[to be printed overleaf]

Fund Required: Rs. ________________________

Approved / Not approved

Suptd.(SRCC) **Joint Registrar (SRCC)** **Dean (R & C)**

Cheque No. ………………… dated …………………… Rs. ……………………. (Rupese ………………….………………………………………………...…….)

Suptd.(SRCC) **Joint Registrar (SRCC)** **Dean (R & C)**

Received the Cheque vide Cheque No…………………………….….dated…………………......

Rs……………………...………(Rupess…………………………………………………...........................)

Receivers signature
Full Name:
Date:

NATIONAL INSTITUTE OF TECHNOLOG DURGAPUR

SPONSORED RESEARCH & CONSULTANCY CELL

TEMPORARY ADVANCE ADJUSTMENT FORM

1) Name of the PI / Co-PI:
2) Department:
3) Title of the Project:
4) Project Sanction Order No:
5) SRCC Registration No:
6) Advance Amount (Rs.):

Date	**Bill No**	**Particulars**	**Amount** (Rs.)	
			Rs.	Paisa
LESS ADVANCE AMOUNT(Rs.)				
NET AMOUNT (Rs.)				

Signature of the PI / Co-PI with Seal

NOTE (if any)

[to be printed overleaf]

Certified that all the articles detailed in the attached Bill / Invoice Rs……………………………..have been duly received in good condition in accordance with Order placed for the purchased and entered in the Measurement Book Page No ___________ also in the relevant Stock Book Page No _________________and that quantities are correct, the quality is good and the rate is not in excess of the accepted rates and suitable notes of payment have been recorded.

Declarations:

1. "I am ____ personally satisfied that these goods are in requisite quality and specification and have been purchased from a supplier with a reasonable price."
2. Amount adjusted **Rs**……………………….. and extra amount **Rs**……………………received.
3. Amount adjusted **Rs**……………………….. and extra amount **Rs**……………………refunded (vide Ch. No………………………dated…………………….

Signature of the PI / Co-PI with Seal

Signature of HOD with Seal

Suptd.(SRCC) **Joint Registrar (SRCC)**

Dealing Assistant (Internal Audit.) **Asstt. Registrar (Internal Audit)**

Dean (R & C)

Cheque No…………………………….….dated………………….......
Rs………………………. (Rupess……………………………………………………….............................)

Receivers signature
Full Name:
Date:

SF-11

SPONSORED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

PURCHASE REQUSITION AND FUND AVAILABILITY FORM

PROJECT CODE	
RECURRING	**NON-RECURRING**

Requisition No.
Date:

Sl. No.	Description of Stores (Name in brief)	Total Value

1. Routine purchase procedure followed:

   If not, give justification (in case of a Proprietary item necessary certificate to be furnished):

2. Purchase order to be placed on:
3. Validity of quotation up to:
4. Terms of payment recommended:
5. In case of foreign purchase
   i) NMI Certificate received from the HOD/ HOC/PI
   ii) Whether DOE clearance certificate obtained:
   iii) Name and address of the Indian Agent:
   iv) Percentage of agency commission (if any):

Signature of the PI

(To be printed at the back of previous page)

7. Fund Availability Equipment / Furniture / Operating

(i) Total grant received / allotted

(ii) Total expenditure incurred including this purchase

(iii) Balance available

Date: Asst. Registrar (SR&C)

Note: Fund booking is required for all purchases.

.COMMENTS OF PRE-AUDIT

1. Vetted / Not vetted
2. Observations, if any
3. Terms of payment
4. Proposal recommended / not recommended.

Audit Officer

The above purchase is approved

Sanctioning Authority

(Director / Dean (R&C))

To

The Asst. Registrar (SR&C)

SF-12

SPONSORED RESEARCH & CONSULTANCY CELL

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

BRIEF RESEARCH ACTIVITY:

Signature of the Principal Investigator with date

Department of (name of the department)
NATIONAL INSTITUTE OF TECHNOLOGY, DURGAPUR
राष्ट्रीय प्रौद्योगिकी संस्थान, दुर्गापुर
MAHATMA GANDHI AVENUE,
DURGAPUR, BURDWAN (W), PIN-713209, INDIA

WO-01

Title : **Item Name**

Work/Purchased Order Number : **NITD/SRCC/PI's dept/PI's code/year/unique_serial num**

Date:

Purchase Order

To,
Vendor name
Address
Phone
PAN: GSTIN:

Supply and installation of following items.

Sl. No.	Description	Qty.	Basic Rate	Total Amount
Total Amount Including GST * :				

Rupees:

Terms and conditions:

i) Prices are all inclusive of taxes, delivery, installation charges for NIT Durgapur.
ii) Delivery to be made at (CSE), NIT, Durgapur within 1 weeks from the date of the purchase order.
iii) Acceptance of the order is to be intimated to NIT, Durgapur within 5 days from the issue of purchase order from NIT, Durgapur.
iv) Free delivery and installation charges for NIT Durgapur.
v) Onsite comprehensive service to be provide 12 months from the date of delivery and installation.
vi) 100% payment shall be made by the purchaser (NEFT etc.) against inspection and final acceptance of item by Indenter. Valid till service period.
vii) Up on delivery of the goods the supplier shall submit the following documents to the purchaser
- 02 copies of invoice showing purchase order no, goods description, quantity unit price total amount.
- 02 copies of delivery challan identifying the contents of each package
- Installation report/certificate, if applicable.

vii) Settlement of any dispute will be made under jurisdiction of Durgapur Court.

Head of Account: head, project registration no. of SRCC

Indenter

SUMMARY SHEET

FOR PAYMENT OF BILLS

DEPARTMENT.. / STORE / LIBRARY / PROJECT No:

1. INDENTER:

Name:..

Department: ....Employer ID: …………………..Mobile:...............................

Signature of Indenter: ....

The Materials are delivered / installed satisfactorily

WO/PO No: .___________________________ dated ....

Signature of Indenter: .... Date:

2. CERTIFCATE FROM DEPUTY REGISTRAR (F&A):

(i) Whether purchase procedure followed: ....

(ii) Whether financial approval obtained: ....

(ii) Financial approval granted by: Director / Registrar/DEAN (R&C)

Signature of Joint Registrar (F&A): Date:

NOTES (IF ANY):

Sponsored Research & Consultancy Cell

राष्ट्रीय प्रौद्योगिकी संस्थान दुर्गापुर

ন্যাশনাল ইনস্টিটিউট অফ টেকনোলজি দুর্গাপুর

NATIONAL INSTITUTE OF TECHNOLGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur – 713209, West Bengal, India

For Head of the Department / Indenter / Purchaser

COVER SHEET

The following information must bear the Cover Sheet while sending any Bill to Finance & Account Section for payment.

1.Name of the Work:-	
2.Estimated Amount approved:-	
3.Date of Notice Inviting Tender:-	4. Numbers of Participants:-
5.Whether Comparative Statement prepared and Checked or not:-	6. Whether lowest rate accepted or not? If not, reasons there of:-
7. Whether GFR-2017/terms & conditions embodied have been followed or not, if not, reasons thereof:-	
8. Purchase/Work Order No. & Date:-	
9. Vendor's Name .-	
10. Vendor's GST Identification Number:-	
11. Vendor's Invoice/Bill No. & Date:-	
12. Vendor's Challan No & Date.-	3. Nos. of days of deviation of supply-
14. Percentage of deviation of work between actual work and work order placed:	
15. Main Gate Entry Register No. Page No.:- SI No..- Date:-	
16. Date of installation of Plant. Machinery, Equipment and its performance report during and after the trial run whether any defects has been noticed or not:-	
17. Extension of time, if any, for supply with approved reasons:-	
18. Stock Book Page No. & Date:-	Measurement Book Page No. & Date-
19. Normal Warranty Period ensured by the supplier:-	
20. Provision of Post-Warranty Service:-	
21 Central Stock Register No. Page No..- Date:-	
22. Head of Account:-	
23. Mode of Payment : ☐ Cheque or ☐ **RTGS/NEFT** along-with Mandate Form (Tick any one)	
	Cheque in favour of .-
For RTGS/NEFT Payment	Vendor/Beneficiary Name:-
	Bank & Branch Name:-
	Account No..- IFS Code:-
24. Recommendation of HOD with Sign. & Seal	Payment may be released Signature of Indenter/Purchaser with Date

Dealing Assistant (Finance & Accounts) | Asst. Registrar/Joint Registrar/Dy. Registrar (F&A)

Dealing Assistant (Internal Audit) | Dy. Registrar (Internal Audit)

REGISTRAR/DEAN (R&C) | **DIRECTOR**

Sponsored Research & Consultancy Cell

राष्ट्रीय प्रौद्योगिकी संस्थान दुर्गापुर

ন্যাশনাল ইনস্টিটিউট অফ টেকনোলজি দুর্গাপুর

NATIONAL INSTITUTE OF TECHNOLGY DURGAPUR

Mahatma Gandhi Avenue, Durgapur – 713209, West Bengal, India

BILL CERTIFICATE / ADJUSTMENT BILL

Certified that all the articles detailed in the attached Bill No.________________dated of M/S for ____________________________ Rs. ___________________Paisa have been duly received in good condition in accordance with the basis of Order placed for the purchase and entered in **Measurement Book Page No** also in the relevant **Stock Book Page No ....** and that quantities are correct, the quality is good and the rate is not in excess of the accepted rates, and that suitable notes of payment have been recorded on the counterfoil of the Order Book and the Suppliers both Original/Duplicate Invoices concerned to prevent double payment. Quotations/Tender were called for the purchase and the lowest rate in respect of the quantity of good is accepted and that the prices originally quoted by the suppliers and is accepted by this office are inclusive/exclusive of sales tax and other charges. In this context, myself undersigned, make the following two mandatory declarations.

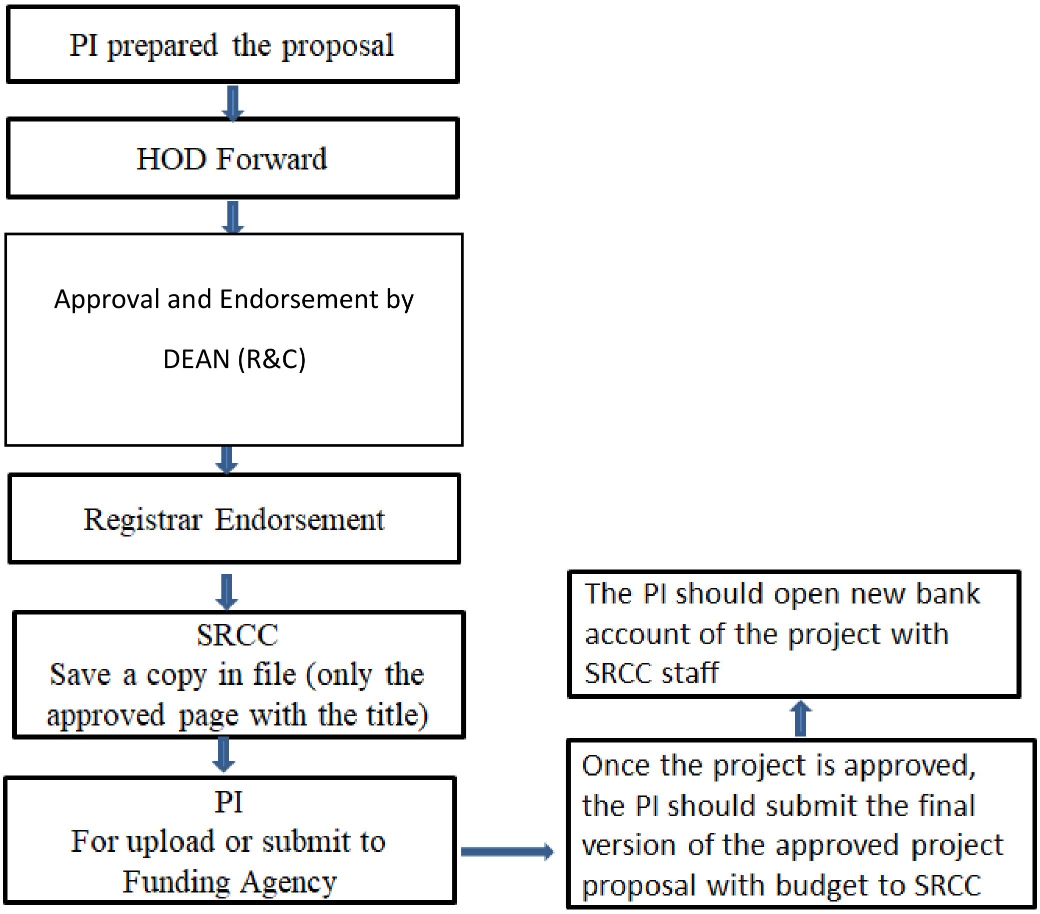
Declarations:

1. "I am _______________________________personally satisfied that these goods are of the requisite quality and specification and have been purchased from a supplier at a reasonable price"
2. "Certified that we members of ____________________________purchase committee are jointly satisfied that the goods recommended for purchase are of the requisite specification and quality, priced at the prevailing market rate and the supplier recommended is reliable and competent to supply the goods in question"

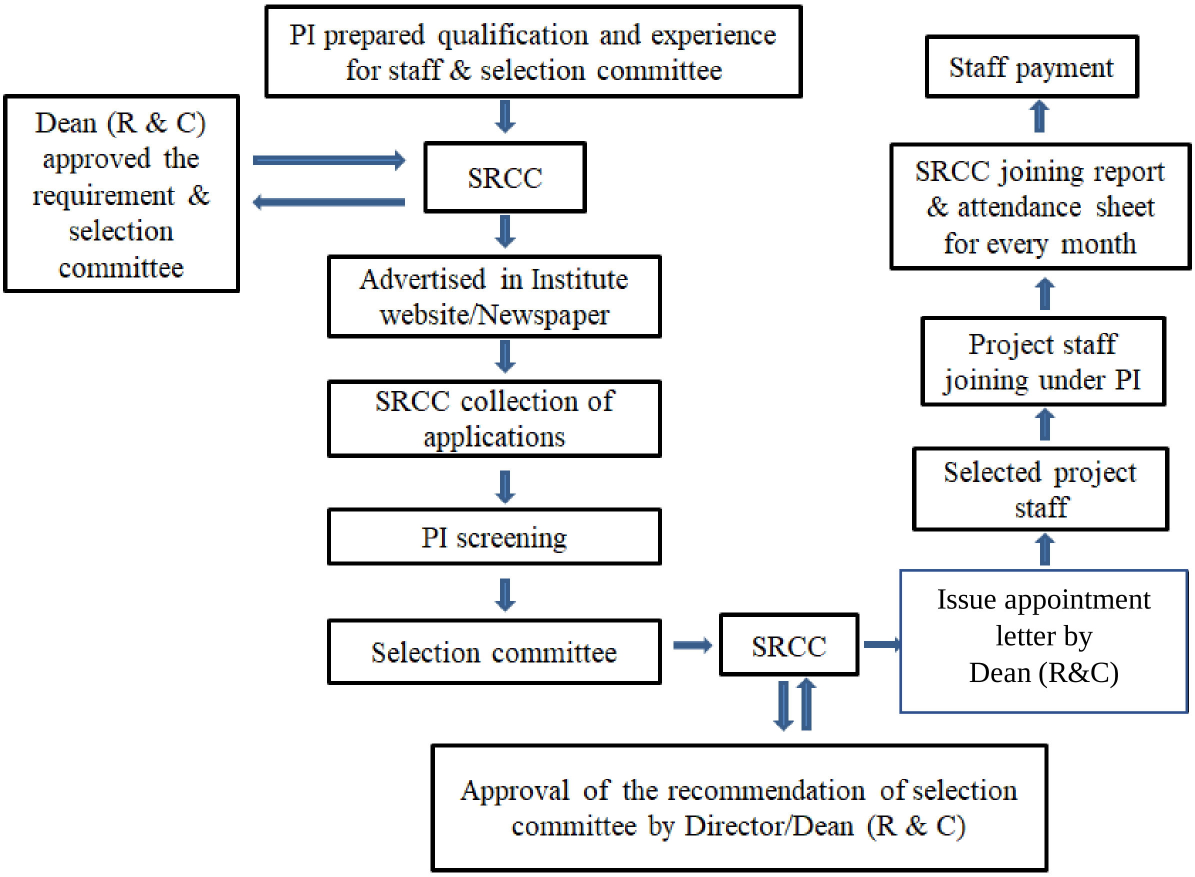
The bill may now be paid out of ....Non Plan/Plan grant for the year 2021 - 2023

Signature of HOD with Seal

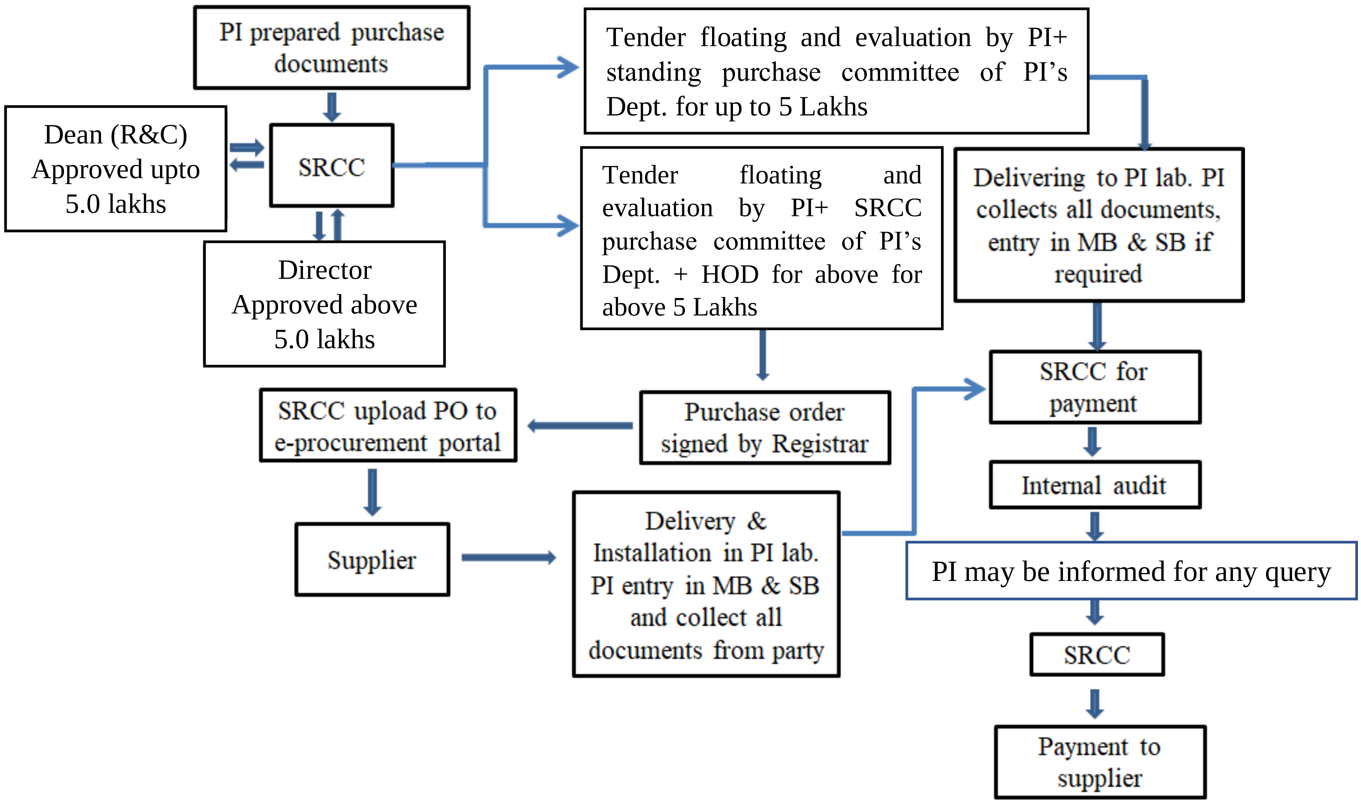
Flowchart for Project Initiation



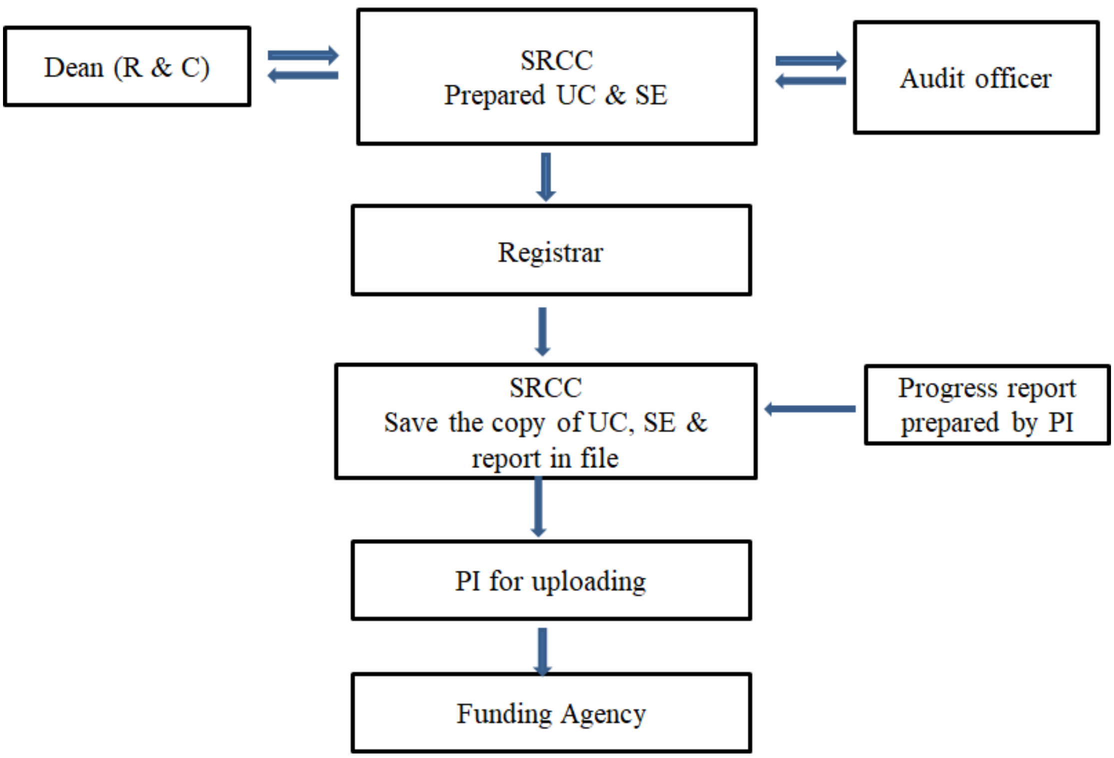
Flowchart for Project Staff Selection



Flowchart for Purchase



Flowchart for Report Submission



Flowchart for Consultancy Project