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 67th Senate dated 20/09/2022 vide Item no: # 67.3

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

CURRICULUM AND SYLLABUS FOR DUAL DEGREE IN CHEMICAL ENGINEERING

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, 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

<table>
<tr><td colspan="7">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="3">Pre-requisites</td><td colspan="4">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="4">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• 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="6">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: 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) / 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="8">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)

Course 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="8">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, 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

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="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>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; 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.]</td></tr>
</table>

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="8">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="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: 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>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)

<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>CYC 331</td><td>CHEMISTRY - II</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">Engineering Chemistry CYC 01</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● 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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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</td></tr>
</table>

	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

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

<table>
<tr><th colspan="8">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>CHC401</td><td>HEAT TRANSFER</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">CHC301, CHC303</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● 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</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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;</td></tr>
</table>

	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, ,Unit Operations of Chemical Engineering ,Harriott .P 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="8">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,</td><td colspan="7"><u>Suggested Text Books:</u>
1. Mass Transfer Operations: R.E. Treybal</td></tr>
</table>

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, ,Harriott .P *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**	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	**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	<u>Suggested Text Books:</u> 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 <u>Suggested Reference Books</u>**:** 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="8">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	<u>Suggested Text Books:</u> 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 <u>Suggested Reference Books:</u> 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="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>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	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)

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	
CHC504	**PROCESS CONTROL AND INSTRUMENTATION**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Knowledge of applied mathematics, Unit operations		CE+MT+EA					
Course Outcomes	● **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.						
Topics Covered	**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. 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	Suggested Text 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	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)

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	Suggested Text Books: 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 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	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

<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>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>
<tr><td>Course Outcomes</td><td colspan="7">●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="7">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.]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><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)</td></tr>
</table>

	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	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 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 2^{nd} 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)

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	<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

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	SuggestedText 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	<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)

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	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)

Course 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	<u>Suggested Text Books:</u> 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, 3rdedition, 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)

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**	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	<u>SuggestedText 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 <u>Suggested Reference Books:</u> 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	SuggestedText Books: 1. Peters, M S, Timmerhaus, KD, Plant Design and Economics, McGraw Hill, 1991 2. Towler G, Sinnott, Ray, Chemical Engineering Design, Elsevier, 2008 SuggestedReference 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.

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)

<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>CHC 715</td><td>MEMBRANE SEPARATION PROCESS</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">CHC 502</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● 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</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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</td></tr>
</table>

	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	<u>Suggested Text Books:</u> 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. <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. 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)

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: 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. **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	<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						

	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

<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>CH 2001</td><td>ADVANCED 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="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic and Undergraduate level Engineering Thermodynamics course</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● 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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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</td></tr>
</table>

	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	<u>Suggested Text Books:</u> 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	<u>Suggested Text Books:</u> 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	Suggested Text Books: 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 Suggested Reference Books: 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	Suggested Text Books: **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. Suggested Reference Books: 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, 2nd 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)