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 BIOTECHNOLOGY

Program Name: Bachelor of Technology and Master of Technology (Dual Degree) in Biotechnology

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR BIOTECHNOLOGY-B.TECH. AND M.TECH (DUAL DEGREE)

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

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

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics - III	3	1	0	4.0	4
2	CHC331	Process Calculation and Thermodynamics	3	1	0	4.0	4
3	BTC301	Cell biology and Genetics	3	1	0	4.0	4
4	BTC302	Microbiology and Bioprocess Technology	3	1	0	4.0	4
5	BTC303	Biochemistry and Enzyme Technology	3	0	0	3.0	3
6	BTS352	Biochemistry Laboratory	0	0	3	1.5	3
7	BTS 351	Microbiology Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	15	4	6	22.0	25
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BTC401	Molecular Biology and Recombinant DNA Technology	3	1	0	4.0	4
2	CHC431	Unit Operation of Chemical Engineering- I	3	1	0	4.0	4
3	BTC402	Immunology	3	1	0	4.0	4
4	CSC431	Programming and Data Structure	3	0	0	3.0	3
5	YYO44*	Open Elective - 1	3	0	0	3.0	3
6	BTS451	Cell Biology and Genetics Laboratory	0	0	3	1.5	3
7	CHS481	Unit Operations of Chemical Engineering-I Laboratory	0	0	3	1.5	3
8	CSS481	Programming and Data Structure Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BTC501	Biochemical Reaction Engineering and Bioreactor Design	3	1	0	4.0	4
2	BTC502	Cell and Tissue Culture	3	1	0	4.0	4
3	BTC503	Bioseparation and Biochemical Analysis	3	1	0	4.0	4
4	CHC531	Unit Operations of Chemical Engineering-II	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	BTS551	Immunology Laboratory	0	0	3	1.5	3
7	BTS552	Bioprocess Technology Laboratory	0	0	3	1.5	3
8	CHS581	Unit Operations of Chemical Engineering Laboratory- II	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	15	4	9	23.5	28

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	BTC601	Bioinformatics	2	1	0	3.0	3
3	CSC631	Database Management System	2	1	0	3.0	3
4	CHC631	Process Control and Instrumentation	2	1	0	3.0	3
5	BTE61*	Depth Elective - 1	3	0	0	3.0	3
6	BTE61*	Depth Elective - 2	3	0	0	3.0	3
7	BTS651	Molecular Biology and rDNA Technology Laboratory	0	0	3	1.5	3
8	BTS652	Bioinformatics Laboratory	0	0	3	1.5	3
9	CSS681	Database Management System Laboratory	0	0	3	1.5	3
10	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	3	9	22.5	27
Semester - VII							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	BTC701	Modern techniques in Biotechnology	3	1	0	4.0	4
3	BTE71*	Depth Elective - 3	3	0	0	3.0	3
4	BTE71*	Depth Elective - 4	3	0	0	3.0	3
5	YYO74*	Open Elective - 4	3	0	0	3.0	3
6	BT1002	Bioprocess Engineering	3	1	0	4.0	4
7	BTS751	Bioseparation and Biochemical Analysis Laboratory	0	0	3	1.5	3
8	BTS752	Cell and Tissue Culture Laboratory	0	0	3	1.5	3
9	BTS753	Biochemical Reaction Engineering Laboratory	0	0	3	1.5	3
10	BTS754	Vocational Training /Summer Internship and Seminar	0	0	2	1.0	2
11	BTS755	Project – I	0	0	3	1.0	3
		TOTAL	18	2	14	26.5	34
Semester - VIII							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BT90XX	Depth Elective - 5	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	BT2001	Genomics , Proteomics and Bioinformatics	3	1	0	4.0	4
5	BT2053	Omics and Bioinformatics Lab	0	0	4	2.0	4
6	BTS855	Thesis Project - I	0	0	6	2.0	6
		TOTAL	12	1	10	17	23

Semester - IX							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	BT90XX	Depth Elective-6	3	0	0	3.0	3
2	BT90XX	Depth Elective -7	3	0	0	3.0	3
3	BT1051	Bioprocess Engineering Laboratory	0	0	4	2.0	4
4	BT3055	Major Project-I	0	0	22	11.0	22
5	BT3056	Major Project Seminar- I	0	0	0	3.0	0
		TOTAL	6	1	26	22.0	33
Semester - X							
Sl.	**Code**	**Subject**	**L**	**T**	**P**	**C**	**H**
1	BT4055	Major Thesis Project - II	0	0	22	11.0	22
2	BT4056	Major Project Seminar-II & Viva Voce	0	0	0	3.0	0
3	BT4057	Comprehensive Viva Voce	0	0	0	1.0	0
		TOTAL	0	0	22	15.0	22

CREDIT UNIT OF THE PROGRAM:

Semester	**I + II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**TOTAL**
Credit Unit	38.0	22.0	22.5	23.5	22.5	26.5	17.0	22.0	15.0	209.0

DEPTH ELECTIVE COURSE BASKETS

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

6th Semester

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

7th Semester

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

8th/ 9thSemester

	DEPARTMENT OF BIOTECHNOLOGY
BT9031	Human Molecular Genetics
BT9032	Cancer Biology
BT9033	Signal Transduction
BT9034	Molecular Cell Signalling
BT9035	Food Biotechnology
BT9036	Biopharmaceutical Technology
BT9037	Biomaterials
BT9038	Biomettalurgy
BT9039	BioEnergy
BT9040	Bioprocess & Plant design
BT9041	Advanced rDNA & Cellular Biotechnology
BT9042	Animal Biotechnology
BT9043	Immunotechnology
BT9044	Molecular Modelling & Drug Design
BT9045	Regenerative Medicine & Translational Research
BT9046	Microbial Biotechnology
BT9047	Environmental Biotechnology
BT9048	Protein structure, folding & misfolding
BT9049	Methods in Computational Biology

BT9050	Nanobiotechnology
BT9051	Plant Biotechnology
BT9052	Metabolic Engineering
BT9053	Nutraceuticals & Nutrigenomics
BT9054	Molecular Plant Pathogen Interactions
BT9055	Cell Biology of Human Diseases
BT9056	Infectious Diseases & Infection Control
BT9057	Project Engineering in Biotechnology
BT9058	Biological Computation
BT9059	Quality by design for Biopharmaceuticals
BT9060	Medical Biotechnology
BT9061	Biological Chemistry
BT9062	BioEntreuprenerurship

DETAILED SYLLABUS

FIRST SEMESTER

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

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						

Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.						
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]						
Text Books, and/or	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech						

reference material	Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications • CO2: To learn fundamentals of polymer chemistry and petroleum engineering. • CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. • CO4: To study few inorganic and bioinorganic compounds of industrial importance.						
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis						

	using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	<u>Suggested Text Books:</u> (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall <u>Suggested Reference Books:</u> **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan

	Inorganic Chemistry: (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application						
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5]						

	Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its						

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

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

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

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	Professional Communication Lab	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment					

	(EA))
None	CT+EA
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	Physics Laboratory	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end					

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

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.						

Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	**WORKSHOP PRACTICE**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes		• CO1: Study and practice on machine tools and their operations • CO2: Practice on manufacturing of components using workshop trades					

	including fitting, carpentry, foundry and welding • CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping • CO4: Develop basic electrical engineering knowledge for house wiring practice
Topics Covered	**M/c shop & Carpentry shop -- 3X3= 9hrs.** • Introduction on machining process. • Introduction to machine tools- Lathe, Shaper, Milling and Drill machine. • Introduction to woods- Types, structure, disease and defect of wood. • Introduction to wood working machines and tools. • Making of dovetail joint and bridle joint. **Welding Shop & Sheet metal -- 3X3= 9hrs.** • Introduction to welding.Safety and precautions in welding. • Formation of weld bead by SMAW on mild steel flat. • Formation of weld bead by oxy-fuel welding on mild steel flat. • Introduction to sheet Metal works. • Tools and Machines used in sheet metal works. • Concept of development, marking out of metal sheets. • Cutting and joining of metal sheets. • Safety precautions, General warning needed in the shop floor. **Black smithy & Foundry -- 3X3= 9hrs.** • Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels. • Safety and precautions in blacksmithy. • Making of bars of different cross-sections. • Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology. • Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing.

	• DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

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

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

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

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

Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana.

- Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi.
- Kriya- Kapalbhati, Trataka.

ATHLETICS

- Introduction of Athletic.
- Starting Technique for Track events- Standing start, Crouch & Block start.
- Finishing Techniques.
- Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules.
- Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance.

BASKETBALL

- Introduction and Players stance and ball handling.
- Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass.
- Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running.
- Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble.
- Rules of Basketball.
- Basketball game.

VOLLEYBALL

- Introduction of Volleyball
- Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service.
- Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set.
- Rules and their interpretation.

FOOTBALL

- Introduction of Football
- Push pass- Instep inside, Instep outer side.
- Kicking- Spot kick, Instep kick, Lofted kick.
- Dribbling- One leg, Both legs, Instep.
- Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping.
- Throwing- Standing throw, Running throw, Seating throw.
- Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick.
- Rules and their interpretation.

CRICKET

- Introduction of Cricket
- Batting gripping & Stance, Bowling gripping technique.
- Batting front foot defense& Drive.
- Batting Back foot defense& Drive.

	• Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc. **NSS**

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

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

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

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

SECOND SEMESTER

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

<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="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic concepts of set theory, differential equations, and probability.</td><td colspan="5">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>
</table>

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

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

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

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

Course Code	Title of the course	Program Core (PCR) /	Total Number of contact hours				Credit
			Lecture	Tutorial	Practical	Total	

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

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

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

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

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

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

	1.2. Definitions of insulator, conductor and semiconductor using band diagram 1.3. Crystalline structure of semiconductor 1.3.1. Covalent bond 1.3.2. Generation of holes and electrons 1.3.3. Effect of temperature on semiconductor 1.4 Intrinsic semiconductor 1.5 Doping and Extrinsic semiconductor 1.5.1 n-Type semiconductor and band diagram 1.5.2 p-Type semiconductor and band diagram 1.5.3 Mass-action law of semiconductor 1.6. Conductivity of semiconductor (including mathematical expression) 1.7 Carrier transport phenomenon. (03 hrs.) 2. **Diodes** 2.1. Construction 2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only) 2.3. Principle of operation with forward biasing and reverse biasing 2.4. Characteristics 2.5 Diode's three models/equivalent circuits.(02 hrs.) 3.**Diode Circuits** 3.1 Diode rectifier 3.1.1 Half wave rectifier 3.1.2 Full wave rectifier:centre tap and bridge rectifier 3.1.3 Capacitive filter and DC power supply (Numerical problems) 3.2 Special Diodes 3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics. 3.2.2 Zener diode as a voltage regulator 3.2.3 Displaydevices: LED and LCD. (03 hrs.) 4.**Bipolar Junction Transistor (BJT)** 4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:**

	classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01 hrs.)
Text Books, and/or reference material	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="7">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="5">Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="5">CT+MT+ EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">Upon successful completion of this course, the student should be able to
• CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts.
• CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment’s
• CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts.
• CO4: introduce the basic concept of single-phase transformer.
• CO5: analyze the transient phenomena in electrical circuits with DC</td></tr>
</table>

Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

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

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

Correlation levels 1, 2 or 3 as defined below:

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

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

Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism. CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody

	c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India. CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution						
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)						
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).						

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

XES52	GRAPHICAL ANALYSIS USING CAD	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union						

	• CO4: Application of C-programming to solve various real time problems
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

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

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

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

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output						

	signals.
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates

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

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

Correlation levels 1, 2 or 3 as defined below:

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

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	ELECTRICAL TECHNOLOGY LABORATORY	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end					

	assessment (EA))
None	CT+EA
Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: understand the principle of superposition. • CO2: understand the principle of maximum power transfer • CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: understand the calibration of energy meter. • CO5: understand open circuit and short circuit test of single-phase transformer. • CO6: analyze RLC series and parallel circuits • CO7: understand three phase connections. • C08: understand determination of B-H curve
Topics Covered	**List of Experiments:** 1. To verify Superposition and Thevenin's Theorem. 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit 9. Determination of B-H Curve for magnetic material
Textbooks, and/or reference material	Textbooks: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru (Author), J M Chuma (Author), H U Ezea (Author) 2. Laboratory Courses in Electrical Engineering (5^{th} Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)

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

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3
CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

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

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

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

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

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

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

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

THIRD SEMESTER

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td>MATHEMATICS-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic knowledge of topics included in MAC01 & MAC02.</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td colspan="3">Course Outcomes</td><td colspan="5">● CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
● CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
● CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
● CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td colspan="3">Topics Covered</td><td colspan="5">Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]
Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange’s interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson’s 1/3 rule for numerical integration; Euler’s method and modified Eular's methods for solving first order differential equations. [14]
Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy’s integral theorem; Cauchy’s integral formula; Taylor’s theorem, Laurent’s theorem (Statement only); Singular points and residues; Cauchy’s residue theorem. [17]</td></tr>
</table>

Topics Covered	**Optimization:** **Mathematical Preliminaries:** Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2] **Linear Programming Problem (LPP):** Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]
Text Books, and/or reference material	Suggested Text Books: 1. An Elementary Course in Partial Differential Equations-T. Amarnath 2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar&R.K.Jain. 3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig Suggested Reference Books: 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

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

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

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

Course Outcomes	● CO1: To develop the concept of dimension and unit conversion to check dimensional consistency of balanced equation ● CO2: Learn basic laws about the behavior of gases, liquids and solids and some basic mathematical tools. ● CO3: To Establish mathematical methodologies for the computation of material balances and energy balances with and without chemical reaction ● CO4: To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries. ● CO5: To analyze and interpret data, to identify, formulate, and solve engineering problems.
Topics Covered	Module - I (10 hrs) ● Significance of Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis Mathematical Requisites: Use of log-log and semi-log graph paper, Triangular Diagram. ● Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another. ● Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial volume, Dalton's law and Amagat's law and Numerical problems on their applications. ● Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications. ● Ideal & non-ideal solutions, Raoult's law, Henry's law and their applications in numerical problems. Module – II (10 hrs) ● Material Balances with and without chemical reaction: Material balances in crystallizers, gas - liquid absorbers, evaporators, distillation plant. Systems with recycle,drying, extraction. ● Energy Balance: Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, liquids and gases. Heat of fusion and vaporization ● Enthalpy calculation for systems with Chemical Reaction, Thermo-chemistry, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Adiabatic Flame Temperature, Theoretical Flame Temperature.

Topics Covered	Module – III (10hrs) ● Scope of thermodynamics, Terminology and fundamental concepts. Microscopic and macroscopic view. State and path functions, thermodynamics processes, Zeroth and First law of thermodynamics: Applications of first law to close and open system.Limitations of first law, Heat pump, heat engine, Second law of thermodynamics: Reversibility and irreversibility, Carnot cycle, concept and estimation of entropy, third law of thermodynamics, Clausiusinequality,Gibb's and Helmholtz free energy. Module – IV (10 hrs) ● PVT behavior of pure substance, Equations of state for ideal and real gases, cubic andvirial equation of state, problems, Compressibility factor,thermodynamic properties of pure substances. ● Refrigeration of gases: Refrigerator, Co-efficient of performance, capacity of refrigerator, Vapour compressioncycle, Choice of refrigerants.
Text Books, and/or reference material	Suggested Text Books: 1. Chemical Process Calculations, D.C. Sikdar, HI Learning Private Limited, 2013 2. Stoichiometry and Process Calculations, K. V. Narayanan, B. Lakshmikutty, PHI Learning (2017) 3. Stoichiometry, Bhatt and Vora, Tata McGraw Hill Companies. 4. Introduction to Chemical Engineering Thermodynamics, GopinathHalder, Prentice-Hall Of India Pvt. Limited, 2009 5. A Textbook of Chemical Engineering Thermodynamics, Narayanan K.V, Prentice 2013 ,2nd edition ;Hall India Learning Private Limited Suggested Reference Books: 1. Unit Operations–Chemical Process Principles – Part-I - Haugen, Wartson&Ragatz (CBS) 2. Basic Principles and Calculations in Chemical Engineering – Himmelblau ((Prentice Hall of India) 3. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill) 4. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley)

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

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

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC 302</td><td>MICROBIOLOGY AND BIOPROCESS TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC01 (LIFE SCIENCE)</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To develop knowledge on different types of microorganisms including viruses and microscopy for the visualization of microorganisms, their characteristic features as well as internal and external structures and their functions.
CO2: To impart an understanding on microbial classification and taxonomy, microbial community and interactions, microbial nutrition, nutritional types, growth media, growthin different systems, and control of microorganisms using various physical and chemical treatments including antimicrobial drugs.
CO3: To develop knowledge on microbial metabolism, energy transduction mechanisms, and microbial genetics
CO4: To acquire experimental know how of microbial production of various industrial products such as alcohol, antibiotics, amino acids, vitamins exopolysaccharides, enzymes, etc. from industrial strains.
CO5: To illustrate the upstream and downstream processing for product recovery and purification.
CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them</td></tr>
<tr><td>Topics Covered</td><td colspan="7">PART A: Microbiology
Introduction to microbiology: History and scope of microbiology, major contribution and events in microbiology, different types of microorganisms – characteristic features, microbes and diseases, microbes in human welfare.[2]
Microbial structures: Different types of microscopy, preparation and staining of specimens, microbial shape, size, arrangements, overview of procaryotic and eucaryotic cell – internal and external structures, cytoplasmic matrix, nucleoid, plasmids, ribosomes, flagella, pilli, fimbrie, spores, bacterial and archaebacterial cell walls and cell membranes, Viruses – types, structures, multiplications [4]
Microbial classification and taxonomy: Domains of life, classification, taxonomic ranks, techniques for determining microbial taxonomy and phylogeny, prokaryotic phylogeny and diversity, microbial community and interactions – Mutualism, Cooperation, Commensalism, Predation, Parasitism, Amenalism, Competition. Normal microbiota of human body. [3]</td></tr>
</table>

Topics Covered	**Microbial nutrition, growth and control:** Common nutrient requirements, nutritional types, uptake of nutrients by cell, culture media, pure culture, microbial growth – batch culture and continuous culture, growth curve, measurement of growth, influence of environmental factors on growth, control of microorganisms by physical and chemical agents, Antimicrobial drugs – general characteristics, narrow-spectrum and broad-spectrum drugs, inhibitors of cell wall synthesis, nucleic acid synthesis and protein synthesis, metabolic antagonists, Drug resistance. [**5]** **Microbial metabolism:** Energy release and conservation, chemoorganotrophic fueling processes, aerobic respiration, glycolysis, TCA cycle, electron transport and oxidative phosphorylation, anaerobic respiration - nitrate and sulphate reduction, fermentations, chemolithotrophy, phototrophy [3**]** **Microbial genetics:** Conjugation, Transduction, Transformation [**4]** **PART B: BIOPROCESS Technology** A) Introduction to Fermentation Technology: Microbial Culture systems; Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; The development of Inoculum for Industrial fermentations; Starter Cultures; Downstream Processing and fermentation economics. …….. **[4]** B) Commercial Strain Development & Microbial Processes: Sources of industrial cultures and maintenance. Alcoholic fermentation: Production of Industrial Alcohol – Fermentation mechanism. Recent developments, brewing and malting, manufacture of wine and other distilled liquors. Cellular control regulating production of microbial metabolites – Primary and Secondary metabolite – Induced mutation technique – Analogue resistant mutant – Catabolic derepressed mutants – Genetically engineered strain – Protoplast fusion technique. Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. **[5]** C) Microbial production of nucleosides and nucleotides: i) Introduction ii) Classification of methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. ……**[3]** D) Microbial production of Vitamins: 1) Vitamin B12 - Organisms used, production method- process, recovery and assay. 2) Vitamin C - Organisms used, production method, process, recovery and assay. **[3]** E) Lectures Microbial Production of Antibiotics : Organism used, production process and recovery of- 1) Bacitracin & 2) Chloramphenicol **[2**] F) Lectures Microbial Production of acids, viz., citric, lactic, Acetic acid, vinegar and gluconic acid. Mechanism of each fermentation, their uses. its spoilage and prevention **[2]** G) Production of Amino acids (Lysine and glutamic acid) and Antibiotics (Pencillin, Streptomycin and Tetracyclines) and its new Developments ……**[2]**

Text Books, and/or reference material	Suggested Text Books: 1. Prescott, Harley and Klein's Microbiology – McGraw Hill 2. Microbiology by Pelczar, Chan and Krieg, Tata Mc Graw Hill 3. L.E. Casida. Jr, Industrial Microbiology, New Age International Publisher 4. W. Crueger, AnneliseCrueger, Biotechnology: A Textbook of Industrial Microbiology, Pnima Publishing Corporation 5. Fermentation microbiology and biotechnology. Ed. E.M.T. El-Mansi , C.F.A. Bryce, B. Dahhou, S. Sanchez, A.L. Demain, A.R. Allman. 3rd ed. Taylor and Francis. Suggested Reference Books: 1. Microbiology by Tortora, Funke and Case 2. Brock Biology of Microorganisms 3. General Microbiology by Hans G Schlegel, Cambridge 4. Atkinson. B and Marituna. F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ.Ltd.4 5. James E Bailey, David F., Ollis, Biochemical engineering fundamentals, second edition. McGraw Hill

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC303	BIOCHEMISTRY AND ENZYME TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	**CO1:** To understand the principles of bioenergetics and to correlate them with the metabolic pathway. **CO2:** To impart an understanding on the fates of macromolecules during metabolism. **CO3:** To provide an understanding on the importance and synthesis of energy currency molecule, ATP. **CO4:** To interpret the regulation in the metabolic pathway and to study the role of hormones in the metabolic pathway. **CO 5:** To understand mechanism and kinetics of enzyme action and their regulation for application of enzymes in living system and for industrial purpose.						

Topics Covered	**Module 1** **(3+2)5** Biomolecules, Vitamins Principles of Bioenergetics **Module 2** **Carbohydrate and its metabolism** **5** **Carbohydrate Biosynthesis** - Gluconeogenesis, Biosynthesis of glycogen, starch, Sucrose , Photosynthetic Carbohydrate Synthesis, **Glycolysis and catabolism of hexoses -** Glycolysis, pentose phosphate pathway of glucose oxidation, Citric acid cycle, regulation of citric acid cycle, glyoxylate cycle . Role of hormones in metabolism **Oxidative Phosphorylation and Photo Phosphorylation** - Oxidative Phosphorylation, Regulation of Oxidative Phosphorylation, Photosynthesis **Module 3** **3** **Lipid and its metabolism** O**xidation of Fatty acids** - Transport of fatty acid, beta-oxidation, Ketone bodies **Lipid Biosynthesis** - Biosynthesis of fatty acids **Module 4** **3** **Protein and its metabolism** **Amino acid oxidation and production of Urea** - Metabolic fates of amino groups, Nitrogen excretion and the urea cycle, Pathways of amino acid degradation Nitrogen metabolism, Biosynthesis of amino acids, **Module 5** **2** **Nucleic acid and its metabolism** Biosynthesis and degradation of Nucleotides **Module 6** **12** **Enzyme Technology and Vitamins** **Enzymes:**Nomenclature of enzymes, Enzyme kinetics, Mechanism of enzymatic, Catalysis, Active site, Activators and inhibitors, Coenzymes, Isoenzymes, Michaelis-Menten equation, Km and Vmax value, Regulation of enzyme activity (single-substrate and multi-substrate reactions). Vitamin's as coenzyme **Production of enzymes and immobilisation** : Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis. Enzyme immobilization: Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme. Engineering of Enzymes **Application of enzyme** in leather industry, detergent industry, dairy industry; Lignocellulose degrading enzymes.
Text Books, and/or reference material	Suggested Text Books: 1. Biochemistry by LubertStryer. W. H. Freeman & Company, NY 2. Biochemistry by Lehninger. McMillan publishers Suggested Reference Books: 1. Biochemistry, Voet&Voet 2. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press 3. Enzyme technology by Chaplin and Bucke. Cambridge Univerity Press

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS351</td><td>MICROBIOLOGY LABORATORY</td><td>PEL</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn and become familiar with types of culture media, preparations of culture media, sterilization procedures, types of equipments.
CO2: To understand the concept of sterility, working principles and applications of instruments: autoclaving, laminar air flow hood etc.
CO3:To learn about the isolation and maintenance process of bacterial cultures.
CO4: To apply the understanding of the cultural and morphological characteristics of microorganisms grown in pure culture.Applications in Antimicrobial effect and
CO5: To interpret microbial growth phases its kinetics specific growth rate.to determine the effects of chemicals on bacteria and to understand the quality of water.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Microbial culture media preparation:
Basic concepts of nutrition materials in media, classes of culture media, how to prepare growth media.
The control of microbial growth :
To study the methods of sterilization: autoclaving, laminar air flow hood, irradiation, filtrations, chemical and gas.
Isolation of microorganisms from an environment of choice :
To demonstrate the ubiquity and diversity of microbes in the environment, samples from immediate areas of the environment will be obtained and cultured and dilution methods.
Isolation and Maintenance of pure cultures :
To study the different techniques of isolation and maintenance of pure cultures: subculturing, streak plate method, pour plate method, spread plate method.
Bacterial morphology and staining :
To study the physical properties and differentiation of microorganisms with the help of different staining procedures: differential and structural staining. Techniques of Gram staining, endospores staining, microscopic study.</td></tr>
</table>

	Estimation of coliform bacteria: To study the estimation of coliform bacteria in water by MPN (most probable number) test. **Study of bacterial growth:** To study the growth pattern of bacteria, specific growth rate calculation, different growth phases of bacteria. **Antimicrobial activity study:** To determine the antibiotic susceptibility via sensitivity disk methods, calculation of zone of inhibition.
Text Books, and/or reference material	Suggested Text Books: 1. Benson HJ. 2002. Microbiological applications: a laboratory manual in general microbiology: McGraw-Hill New York, NY. 2. Harley JP. 2004. Laboratory exercises in microbiology: McGraw-Hill Science/Engineering/Math Suggested Reference Books: 1. Brown AE. 2009. Benson's Microbiological Applications: Laboratory Manual in General Microbiology, Short Version: McGraw Hill 2. Madigan MT, Martinko JM, Dunlap PV, Clark DP. 2012. Brock biology of microorganisms: Pearson/Benjamin Cummings. 3. Pollack RA. 2004. Laboratory exercises in microbiology, 3e. Recherche 67: 02

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS352	BIOCHEMISTRY LABOARTORY	PCR		0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To design , analyze and solve problems and learn to plot graph and interpret data CO2: To develop skills to perform experiments and have hands on training. CO3: To apply the results and data to solve problems in daily activities and industry.						

Topics Covered	1. To prepare Tris-HCl Buffer with a specific pH (eg. pH 8.8) 2. Qualitative and quantitative estimation of carbohydrates 3. Qualitative and quantitative estimation of aminoacids and determination of the unknown concentration of protein concentration by plotting a standard curve of BSA using Bradford reagent 4. Ammonium sulphate precipitation and dialysis for a protein 5. Separation and Identification of Amino acids by Paper Chromatography and Thin Layer Chromatography 6. Analysis of Protein purity and determination of molecular weight of pure protein by SDS PAGE and Coomassie Brilliant blue staining of proteins on SDS gel 7. Extraction of Enzyme Tyrosinase from commercially available mushrooms and Assay of Enzyme Tyrosinase with determination of specific activity of Enzyme Tyrosinase 8. Effect of substrate concentration on the activity of Enzyme Tyrosinase and determination of MichelesMenton parameters of Enzyme Tyrosinase 9. Effect of inhibitor concentration on the activity of Enzyme Tyrosinase
Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry by David T Plummer Suggested Reference Books: 2. Biochemistry by Voet and Voet

FOURTH SEMESTER

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC401</td><td>MOLECULAR BIOLOGY AND rDNA TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01 Life Science
BTC301 Cell Biology and Genetics
BTC303 Biochemistry and Enzyme Technology</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will acquire basic understanding of molecular biology topics: nucleic acid structure and chemistry; organization of genome in chromosomes; regulation of replication, transcription, translation and DNA repair.
CO2: Students will acquire knowledge of recombinant DNA techniques on: nucleic acid amplification and gene cloning; manipulation of DNA sequences; preparation and screening of nucleic acid libraries; gene silencing; analysis of variations in genome sequence.
CO3: Students will be proficient in applying basic understanding of molecular biology topics in analyzing and solving problems related to recombinant DNA technology.
CO4: Students will be able to design strategies to solve problems related to recombinant DNA technology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Nucleic acid structure: Nucleotides and nucleic acids, DNA structure, different forms of DNA, unusual DNA structure, different types of RNA, RNA structure. [3]
2. Nucleic acid chemistry: Denaturation and renaturation, hybridization, nonenzymatic transformation (Mutation) – spontaneous and induced, point mutation - transition, transversion, mutation involving more than one base pairs, insertion, deletion, frame shift mutation, forward and back mutation, null mutation, Loss-of-function and gain-of-function mutation, silent mutation, DNA sequencing. [4]
3. Chromosome organization: Chromosomal elements – genes and intergenic regions, regulatory sequences; DNA supercoiling, linking number, Chromosome structure: Histones, Non-histones, Nucleosome, Chromatin. Chromosome structure in prokaryotes & eukaryotes. [4]</td></tr>
</table>

	4. DNA replication and repair: Central dogma, DNA replication in prokaryots and eukaryots – set of fundamental rules, DNA polymerases, proteins and enzymes involved in replication, process, accuracy. [4] 5. Transcription and post-transcriptional processing: DNA-dependent RNA synthesis in prokaryotes and eukaryotes, RNA polymerases, transcription process, termination, selective inhibition, RNA processing – capping, splicing of introns, differential RNA processing; RNA-dependent synthesis of RNA and DNA. [4] 6. Protein synthesis – translation: Genetic code, ribosome, transfer RNA, protein biosynthesis stages – attachment of amino acid to specific tRNA, initiation, elongation, termination, folding and processing; inhibition of protein synthesis. [4] 7. DNA repair: DNA repair – multiple repair systems. [3] 8. Regulation of gene expression: Regulation of gene expression in bacteria - operon concept; Regulation of gene expression in eukaryotes, hormonal control of gene expression in eukaryotes. [3] 9. Introduction to recombinant DNA and Gene Cloning Tools of recombinant DNA: Vectors; plasmid, bacteriophage viral vectors, cosmids, yeast artificial chromosome. Expression vectors, and selection of suitable Host. [5] 10. Restriction endonucleases and other enzymes use and mechanism of action and analysis, Genomic DNA and cDNA library preparation. Strategies for engineered vectors use and regulation for enhanced gene expression and purification. [5] 11. Screening and selection of clone with desired gene and protein of interest: Colony and plaque hybridization. antibody based assay, Protein activity. Application of gene cloning and DNA Analysis. [3] 12. Molecular probes: Preparation of molecular probes DNA probes, RNA probes, radioactive labeling, Non-radioactive labeling, use of molecular probes in DNA fingerprinting. Southern blotting, Northern blotting, Western blotting, In-situ hybridization. [4] 13. MOLECULAR TECHNIQES: Polymerase chain reaction, different types and their use. Antisense RNA technology, Site directed mutagenesis, Use of RFLP, SNP and Microarray. [4]
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Gene IX by B. Lewin, Pearson 2. Molecular biology of the cell by Albertset. al., Garland science <u>Suggested Reference Books:</u> 1. Molecular Biology of the Gene, 7th edition 2013. Watson et. al. Published by Pearson. 2. Cell and molecular Biology, Concepts and experiments Gerald Karp, John Wiley and Sons. 3. The Cell - A molecular approach, GM Cooper ASM Press 4. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd

<table>
<tr><td colspan="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>CHC431</td><td>UNIT OPERATIONS OF CHEMICAL ENGINEERING I</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Mathematics, Unit Operations</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CA1:To Understand fundamentals of fluid dynamics and mechanics
● CA2:Understanding the fundamentals of heat transfer operations
● CA3:To learn design of heat transfer equipment and calculations
● CA4:To develop knowledge of different mechanical operations and their applications
● CA5:To solve related problems of different difficulty levels through tutorials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module - I (14 hrs)
Fundamental Concepts: Definition of Fluid, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; flow visualization – streamline, path line, streak line, viscosity; Newtonian fluid; Non-Newtonian fluid; Reynold's number—its significance, laminar, transition and turbulent flows.
Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices– manometer, U-tube, inclined tube. Introduction to rotational and irrotational flow. Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor.
Fluid moving machines: Introduction; Basic classification of pumps: Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); Peristaltic pump; Pump specification; Basic characteristics curves for centrifugal pumps
Module – II (14 hrs)
Basic modes of heat transfer; Heat transfer by conduction: One dimensional steady state heat conduction, Fourier's Law, Thermal conductivity, Compound resistance in series; Steady state heat transfer analysis through extended surface; Unsteady state heat conduction with and without heat generation, Concept of thermal diffusivity; Concept of heat transfer coefficient in convective-conductive system, Critical thickness of insulation.</td></tr>
</table>

	Heat transfer by convection: Convection heat transfer mechanism; Forced convection in systems of simple geometrics (plate, cylinder etc.), Thermal boundary layer; Co-relation for heat transfer coefficient: internal flow & external flow, Momentum & heat transfer analogies. Evaporation: Classification; Capacity, Steam economy; Boiling point elevation (Duhring rule); Material and energy balance of single effect evaporator; Introduction to multiple effect evaporator: Forward feed, Backward feed, Mixed feed, Parallel feed Module – III (12 hrs) Particulate solids: Characterization of solid particles, particle shape, particle size, mixed particle sizes and size analysis, specific surface of mixture, average particle size. Screen analysis: Type of screens, ideal screen, real screen, screen effective ness, differential and cumulative analysis, screen capacity. Screening equipment: stationary screens and grizzlies, gyrating screens, vibrating screens and other industrial screens like trammels etc. Comminution of solids (Size Reduction): Factors affecting commnution, comminution laws: Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption.
Text Books, and/or reference material	Suggested Text Books: 1. A Textbook of Fluid Mechanics And Hydraulic Machines, R.K. Bansal, Laxmi (2018 ,Tenth edition ;Publications 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. 3. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 4. Mechanical Operations for Chemical Engineers, C.M. Narayanan and B.C. Bhattacharya, KHANNA PUBLISHERS, 1990 Suggested Reference Books: 1. Process Heat Transfer: D. Q. Kern, MGH, 1983 2. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977 3. Principles of Unit Operations by Alan S Foust, L.A. Wenzel, C.W. Clump, L. Maus, and L.B.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 402	IMMUNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01		CT+MT+EA					

Course Outcomes	CO1: To understand the role of the components of the immune system and its classification CO2: To understand the role of the immune cells and their immunological response in the context of human diseases including infectious diseases, autoimmunity, and cancer. CO3: To learn the fundamentals and principles of immunological techniques and their application. CO4: To understand methods of generations of Polyclonal and Monoclonal Antibody and the use of custom made genetically engineered antibodies. CO5: To solve problems associated with drugs and their toxic response based on the knowledge of immunological response.
Topics Covered	**Immunology-** fundamental concepts and anatomy of the immune system Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system-primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing (6) **Immune responses generated by B and T lymphocytes** Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; (2) Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily (3) Kinetics of Active and Passive Immunity, Basis of self –non-self discrimination; (4) B cell maturation, activation and differentiation; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses (6) Hypersensitivity, Antibody Dependent Cell Cytotoxicity; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation Hapten-carrier system. Complement system. (4) **Antigen – Antibody Interaction dependent Techniques** Precipitation, Agglutination; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, Immuno-electron microscopy and Immuno flourescence techniques (6) **Clinical Immunology:** Preparation and clinical uses of Monoclonal and Polyclonal antibody. (3) Transplantation; Autoimmunity; (5) Vaccination: Principles and development of vaccines against different diseases. (3)
Text Books, and/or reference material	Suggested Text Books: 1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications. 1999 Suggested Reference Books: 1. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002. 2. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999. 3. Goding, Monoclonal antibodies, Academic Press. 1985.

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC431</td><td>PROGRAMMING AND DATA STRUCTURE</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Knowledge of Programming Language</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Understanding of the fundamental concepts of data, data types and abstract data types.
● CO2: Implementation of different abstract data types using different data structures.
● CO3: Apply different types of data structures to implement different solutions to problems.
● CO4: Analysis of the suitability/compatibility of different data structures based on the types of applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1) Introduction: Basic terminology, elementary data organization, structure operations, algorithm, complexity and time-space trade-off. [2]
2) Arrays: Array definition, representation and analysis, single and multidimensional arrays, address calculation, application of arrays, character string in c, character string operation, array as parameters, ordered list, sparse matrices and vectors. [4]
3) Stacks: Array representation and implementation of stack, operations on stacks: push AND pop, array representation of stack, linked representation of stack, operations associated with stacks, application of stack: conversion of infix to prefix and postfix expressions, evaluation of postfix expression using stack. [5]
4) Queues: Array and linked representation and implementation of queues, operations on queue: create, add, delete, full and empty, circular queues, d-queues and priority queues. [4]
5) Linked list: Representation and implementation of singly linked lists, two-way header list, traversing and searching of linked list, overflow and underflow, insertion and deletion to/from linked lists, insertion and deletion algorithms, doubly linked list, linked list in array, polynomial representation and addition, generalized linked list, garbage collection and compaction. [7]</td></tr>
</table>

	6) Trees: Basic terminology, binary trees, binary tree representation, algebraic expressions, complete binary tree, extended binary trees, array and linked representation of binary trees, traversing binary trees, threaded binary trees, traversing threaded binary trees. [7] 7) Searching: Sequential search, binary search. [2] 8) Sorting: Insertion Sort, Selection Sort, Bubble Sort, Radix Sort, Quick Sort, Merge Sort and Heap Sort. [8] 9) Binary Search Trees: Binary Search Tree (BST), Insertion, Deletion and Search Operations in BST. [5] 10) Height Balance Tree: Introduction to Height Balance Tree, Insertion, Deletion and Search Operations in Height Balance Tree. [5] 11) Graphs: Terminology and representations, graphs and multi-graphs, directed graphs, sequential representations of graphs, adjacency matrices, traversal, connected component and spanning trees, minimum cost spanning trees. [7]
Text Books, and/or reference material	Suggested Text Books: 1. Horowitz and Sahani, "Fundamentals of data Structures", Galgotia Publication Pvt. Ltd., New Delhi. 2. R. Kruse etal, "Data Structures and Program Design in C", Pearson Education Asia, Delhi-2002 3. A. M. Tanenbaum, "Data Structures using C & C++", Prentice-Hall of India Pvt. Ltd., New Delhi Suggested Reference Books: 1. Bruno R Preiss, "Data Structures and Algorithms with Object Oriented Design Pattern in C++", Jhon Wiley & Sons, Inc. 2. 6. Adam Drozdek, "Data Structures and Algorithms in C++", Thomson Asia Pvt. Ltd.(Singapore)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO 441	FOOD BIOTECHNOLOGY	PER/OER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01		CT+MT+EA					

Course Outcomes	CO1: To quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation and increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.
Topics Covered	**Food Microbiology:** **[8]** Microorganism in food, Intrinsic and extrinsic parameters of food**,** rapid methods for identification of microorganism in food, Food borne illness, Biosensors –use and application **Food preservation** **[8]** Pasteurization, sterilization, Canning, thermal process of food with numericals, Irradiation, Dehydration, low temperature , use of preservatives **Food fermentation** **[10]** **Role of lactic acid bacteria in fermentation and strain improvement**, Fermentation of meat, fish, vegetables, beverages, dairy product, non-beverage product , use of genetic engineering techniques for improved quality product**.** **Genetically modified food** **[8]** Fruit ripening, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Ethical and regulatory issues **Biotechnology in relation to food product** **[4]** Antioxidant, nutraceutical, **Food safety** **[6]** Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series, detection of toxin, heavy metal , pesticide and herbicides
Text Books, and/or reference material	Suggested Text Books: Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Suggested Reference Books: Fundamentals of Food Biotechnology by Lee

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS451	CELL BIOLOGY AND GENETICS LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Cell Biology and Genetics (BTC301)	CT+EA

Course Outcomes	CO1: To design, analyze and solve problems related to cell biology and Molecular genetics and interpretation of data obtained by the lab experiments. CO2: To develop skills to perform experiments related to cell biology and Molecular genetics and have hands on training on the related area. CO3: To learn to interpret data, draw conclusion and develop trouble shooting skills.
Topics Covered	1. Isolation of chromosomal DNA from mammalian cells. 2. Genotyping PCR of a genetically modified cell. 3. Isolation of mRNA and RT-PCR to determine the level of transcription of the gene. 4. Studying to detect variations like single nucleotide polymorphism. 5. Studying bacterial conjugation. 6. To examine the morphology of cells 7. Identification of cellular organelles by staining method 8. Cell proliferation assay 9. Cell adhesion assay 10. Cell migration assay
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: ● Molecular Biology of Cell by Albert et.al. John Wiley & Sons ● The Cell by Cooper. ASM Press ● M.W.Strickberger: Genetics, Pearson.

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

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

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS481	PROGRAMMING AND DATA STRUCTURE LABORATORY	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Knowledge of Programming Language		CT+MT+EA					

Course Outcomes	● CO1: Choose appropriate data structures for representation and manipulation of the data for the given problems. ● CO2: Handle operations like search, insertion, deletion, traversing and sorting on various data structures. ● CO3: Have knowledge on the applications of linear and non-linear data structures for real life problems. ● CO4: Able to store and manipulate data in an efficient manner. ● CO5: Able to implement stack, queue, binary tree, etc. using arrays and linked lists. ● CO6: Able to apply the concepts learnt through thiscourse in various domains like DBMS and compiler.
Topics Covered	**Linked List** ● Implementations of Linked Lists menu driven program ● Implementation of different operations on linked list – copy, concatenate, split, reverse, count no. of nodes etc. ● Representation of Sparse matrix using multilinked structure. Implementation of sparse matrix addition and multiplication ● Implementation of polynomial operations (addition, subtraction) using Linked List ● Implementations of Doubly Linked List **Stack** ● Implementations of stack menu driven program using array and linked list ● Implementation of multi-stack in one array ● Implementations of Infix to Postfix Transformation and its evaluation program ● Implementations of Infix to Prefix Transformation and its evaluation program **Queue** ● Implementations of double ended queue menu driven program using array and linked list ● Implementations of circular queue menu driven program using array and linked list ● Implementation of Priority queue program using array **Tree** ● Implementations of Binary Tree menu driven program ● Implementation of Binary Tree Traversal program ● Implementations of BST program ● Implementation of various operations on tree like – copying tree, mirroring a tree, counting the number of nodes in the tree, counting only leaf nodes in the tree **Sorting** ● Implementations Insertion sort, Selection sort, Bubble sort and Quick sort menu driven program **Searching** 12) Implementations of Sequential and Binary Search menu driven program

Text Books, and/or reference material	Suggested Text Books: 1. Horowitz and Sahani, "Fundamentals of data Structures", Galgotia Publication Pvt. Ltd., New Delhi. 2. R. Kruse etal, "Data Structures and Program Design in C", Pearson Education Asia, Delhi-2002 3. A. M. Tanenbaum, "Data Structures using C & C++", Prentice-Hall of India Pvt. Ltd., New Delhi Suggested Reference Books: 1. Bruno R Preiss, "Data Structures and Algorithms with Object Oriented Design Pattern in C++", Jhon Wiley & Sons, Inc. 2. Adam Drozdek, "Data Structures and Algorithms in C++", Thomson Asia Pvt. Ltd.(Singapore)

FIFTH SEMESTER

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC 501</td><td>BIOCHEMICAL REACTION ENGINEERING AND BIOREACTOR DESIGN</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 – To gain knowledge about Chemical and Biochemical processes, order of reactions, effect of various parameters on rate constant of a reaction
C02- To study about different reactions in batch reactors, kinetics of enzyme catalyzed reactions
CO3- To acquire knowledge about different ideal and non-ideal reactors, reaction kinetics, microbial growth kinetics
CO4- To learn about various types of Bioreactors, their design considerations and applications in the field of Biochemical Engineering
CO5- To study about mass transfer in bioprocess systems, scale up, instrumentation and control, bioreactor considerations in plant and animal cell culture</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction. [5]
Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes.–derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive. [5]
Fundamentals of homogeneous reactions for batch, plug flow and mixed flow reactors. [5]
Concept of ideal and non ideal reactors, Residence time distribution, Models for non ideal reactors (Dispersion model, tanks-in-series model). [5]</td></tr>
</table>

	Stoichiometry of cellular reactions. Microbial growth kinetics (Batch, continuous, fed batch). Monod model and other kinetic models. Growth kinetics with plasmid instability. [6] Bioreactor design: Packed bed bioreactor, Fluidized bed bioreactor, Bubble column bioreactor, Air lift bioreactor, Tower bioreactor. Hollow fiber bioreactor, Membrane bioreactor. [4] Design of fermenter. Fermenter utilities – boiler and refrigeration system. [5] Immobilized cell bioreactor system. Mass transfer in bioprocess system. Two film theory, K_{la} determination. Scale up concepts. Bioreactor considerations for plant and animal cell culture [5] Bioprocess instrumentation and control. Computer controlled bioreactors. [2]
Text Books, and/or reference material	<u>Suggested text books:</u> 1. Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. 2. Bioprocess Engineering Principles – Pauline M Doran. Academic press 3. Chemical Reaction Engineering ,O Levenspiel, Wiley 4. Principles of Fermentation Technology, Stanbury and Whitaker, Pergamon press <u>Suggested reference books:</u> 1. Biochemical Engineering. Fundamentals, Bailey &Olis, McGraw-Hill 2. Biochemical Engineering, Humphrey and Aiba. Academic Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC502	CELL AND TISSUE CULTURE	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01 Life Science BTC301 Cell Biology and Genetics		CT+MT+EA					
Course Outcomes	**CO1:** Students will acquire knowledge on plant and animal cell and tissue growth conditions. **CO2:** Students will be acquainted with plant and animal cell and tissue culture techniques in laboratory and industry setups. **CO3:** Students will be proficient in applying basic understanding of plant and animal cell and tissue growth requirements in plant and animal tissue culture techniques.						

Topics Covered	1. Introductory history, plant & animal cell culture facilities laboratory organization, media & aseptic conditions. [2] 2. Plant growth hormones, Cell culture, cellular totipotency, somatic embryogenesis, anther, pollen and ovary cultures, protoplast culture. [6] 3. Haploid production, triploid production, in vitro pollination and fertilization, zygotic embryo culture, somatic hybridization and cybridization, genetic transformation, somaclonal and gametoclonal variant selection. [7] 4. Production of disease-free plants, clonal propagation. [3] 5. Industrial applications: secondary metabolite production, germplasm conservation. [3] 6. Animal Cell Culture: Historical Background. [1] 7. Importance of and progress in Animal Cell Culture Technology. [1] 8. Biology of Animal Cell; Cellular Interactions. [5] 9. Importance of Serum and Serum Free Media. [2] 10. Culturing and Sub-Culturing of Animal Cells. [3] 11. In Vitro Transformation of Animal Cells. [1] 12. Cell Differentiation & Cell Movement. [2] 13. Cloning of Animal Cells. [2] 14. Cell Line Preservation. [1] 15. Cell Line Characterization. [2] 16. Chromosome Spreading and Karyotype Analysis. [2] 17. Mycoplasma: Detection and Control. [1] 18. Monoclonal Antibody Production. [2] 19. Insect Cell Culture: An Overview. [2]
Text Books, and/or reference material	Suggested Text Books: 1. Razdan – Introduction to Plant Tissue Culture, 2nd edition, 2007, Oxford and IBH Publishing. 2. "Culture of AnimalCells: A manual of basic technique", 4 th Edition Author(s)/Editor(s): Freshney RI. Publisher: WIELY-LISS ISBN:0-471-34889-9. Suggested Reference Books: 1. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice, a revised edition, 2009, Elsevier. 2. Jha and Ghosh – Plant Tissue Culture: Basic and Applied, revised 2nd edition, 2016, Platinum Publishers.

Department of Biotechnology

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC503	BIOSEPARATION AND BIOCHEMICAL ANALYSIS	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					

Basic Physics, Mathematics including basics of Differential & Integral Calculus, Basic concepts of Chemistry & Biochemistry	CT+MT+EA
Course Outcomes	CO1: To learn the concepts of separation including purification sequence and its monitoring and the properties of proteins underlying bioseparations. CO2: To learn techniques of biochemical analysis of biomolecules. CO3: To learn and analyze, mathematically wherever applicable, the various unit operations in bioseparation. CO4: To understand the design aspects of unit operations in bioseparation. CO5: To solve problems of bioseparations including industrial bioseparations.
Topics Covered	**Basic Concepts** **[3]** Basic concepts of Bio-separation Technology **Basic Analytical Tehniques:** **[10]** Introduction to Biomolecules, Buffers Estimation of carbohydrate, protein, and lipid, and enzyme assay Quantitation of DNA and RNA Methods of cell disintegration **Removal of Insolubles** **[9]** Flocculation and conditioning of broth. Filtration at constant pressure and at constant rate; equations for batch and continuous filtration, centrifugal and cross-flow filtration. Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications. **Techniques Involved in Separation Processes for Solutes** **[9]** Foam-fractionation; Solvent extraction, aqueous two-phase extraction, adsorption & desorption processes; Salt precipitation Membrane based separation processes:Micro-filtration, Dialysis, Reverse osmosis, Ultrafiltration and affinity ultrafiltration, concentration polarization, rejection, flux expression, membrane modules, dead-end and cross-flow modes. **Advanced Techniques for Bioseparation:** **[9]** Chromatography: paper chromatography, TLC, gel filtration, ion exchange, hydrophobic interaction chromatography, affinity chromatography, HPLC. Electrophoresis: Theory and application of Polyacrylamide and Agarose gel electrophoresis; 2D-Gel electrophoresis **Industrial Application with an example** **[2]**

Text Books, and/or reference material	Suggested Text Books: 1. Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Suggested Reference Books: 1. D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 2. Shuler & Kargi, Bio-process Engg. PHI 3. Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC531	UNIT OPERATIONS OF CHEMICAL ENGINEERING-II	PCR	3	1	0	4	4
CHC431: Unit operations of chemical engineering-I.		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes		● To learn different types of mass transfer phenomena ● Understanding the fundamentals of mass transfer operations ● To learn design parameters, their effects and calculations ● To compare different types of mass transfer operations and their applications ● To solve related problems of different difficulty levels through tutorials					
Topics Covered		**Module I:** Principles of mass transfer: Introduction, diffusion, classification of diffusion, Inter-phase mass transfer. [8 hr] **Module II:** Evaporation: Introduction, types of evaporators, design calculation and processes [8 hr] **Module III:** Drying: Principles of drying, drying characteristics, methods, equipment. Humidification and Dehumidification: Definitions, adiabatic saturation temperature, wet bulb temperature, processes [8 hr] **Module IV:** Absorption: Principle, operation and design calculation [8 hr] **Module V:** Distillation: Flash distillation, differential distillation, fractionation and design calculations [8 hr] **Module VI:** Extraction and Adsorption: Principles and Operations. [8 hr]					

Text Books, and/or reference material	Suggested Text Books: 1. B.K.Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Private Limited 2. N Anantharaman and K.M.M.S. Begum, Mass Transfer theory and practice. Prentice Hall India Private Limited 3. Robert E. Treybal, Mass Transfer Operations, McGraw Hill limited Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO540	MINERAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	● CO1: To understand the nature and characteristics of different biogeochemical cycles and involvement important micro-organisms. ● CO2: To learn the basic concepts of bioleaching and biobeneficiationalong with the microbiological aspects ● CO3: To gain the detail knowledge bioleaching processes with examples. ● CO4: To demonstrate and provide examples on how to use microbes for the environmental pollution control
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8

Text Books, and/or reference material	Suggested Text Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology , Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235 , 1983 Suggested Reference Books: 1. Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO541	INTRODUCTION TO COMPUTATIONAL BIOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Life Science BTC01		CT+MT+EA					
Course Outcomes	● CO1: To impart knowledge of life science and biological data ● CO2: To acquire knowledge of computational and mathematical skills for addressing important biological questions. ● CO3: To learn how to develop and implement computational algorithms and tools for processing biological data						
Topics Covered	1. Introduction to Computational biology and its applications(2) 2. Central dogma and biological macromolecules- DNA, RNA & proteins(2) 3. Major biological databases related to DNA, RNA, proteins &metabolic pathways(3) 4. Basic file formats & sequence representation(2) 5. Computational algorithms for Sequence Alignment: Local and global alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7) 6. Algorithms for phylogenetics: Tree constructions(5) 7. Structural Bioinformatics: A. Protein Structure and its visualization(2) B. Protein structural alignment(3) C. Protein secondary Structure Prediction(4) D. Protein tertiary Structure Prediction(4) E. RNA Structure Prediction(3) F. Molecular docking and docking algorithms(3) 7. Application of machine learning in biological sciences (Basic concepts) (2)						

Text Books, and/or reference material	Suggested Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. Introduction to Bioinformatics by Arthur MLesk Suggested Reference Books: 1. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R.Taylor. 2. Essentials of Bioinformatics by JinXiong

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

Text Books, and/or reference material	Suggested Text Books: 1. Immunology Laboratory manual. 2. ArtiNigam,ArchanaAyyagari,"Lab Manual in Biochemistry, Immunology and Biotechnology",McGraw Hill Education, India, 2007 Suggested Reference Books:

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

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

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

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

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

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

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC631	DATABASE MANAGEMENT SYSTEM	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1: Understand the basic concepts and appreciate the applications of database systems CO2. Comprehend the fundamentals of design principles for logical design of relational databases CO3: Apply the query writing skill CO4. Discuss the basic issues of transaction processing and concurrency control
Topics Covered	1. Introduction of DBMS. 5L 2. Concept of E-R diagram, Extended E-R diagram. 5L 3. Relational Algebra 4L 4. Queries with various operations 4L 5. SQL Queries 4L 6. Index structure design 5L 7. Normalization (Different normal forms) 5L 8. Basic concepts on transaction processing 5L 9. Various concurrency-control protocols (2 phase locking, time stamp protocol) 5L
Text Books, and/or reference material	Suggested Text Books: 1. Silberschatz, H. F. Korth and S. Sudharshan, "Database System Concepts", Sixth Edition, Tata McGraw Hill, 2011. 2. R. Elmasri, S. B. Navathe, "Fundamentals of DBMS Systems", Pearson education. Sixth Edition. 3. Kahate, "Introduction to Database Management Systems", Pearson Education, New Delhi, 2006. Suggested Reference Books: 1. C.J.Date, A.Kannan and S.Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006.

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC631	Process Control & Instrumentation	PCR	2	1	0	3	3
Mathematics, Unit Operations		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	● CO1: Analyze open-loop system ● CO2: Analyze and apply the knowledge of linear closed-loop systems. ● CO3: Develop working knowledge of control system by frequency response ● CO4: Analyze the response of instruments and ability to integrate knowledge about instrument ● CO5:Explain the importance and application of instruments
Topics Covered	Laplace Transform, 1st order response, 1st order in series, linearization, 2nd order Dynamics (12) Feedback control system, Servo and regulator problem, Transfer function of Controller, Final control element, Control valve characteristics, Transportation Lag, Routh-Hurwitz Criteria and stability (12) frequency response of closed-loop, frequency response technique, Bode Diagram and stability criteria (8) Static and dynamic responses, Measurement of temperature and pressure (5) instruments for process plant to measure flow, level and concentration of fluid (5)
Text Books, and/or reference material	Suggested Text books: 1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. Chemical Process control, G. Stephanopoulos, PHI, 2008 3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996) 4. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000) Suggested Reference Books: 1. Jone's Instrumentation Technology (all the volumes) 2. Instrumentation and Devices by Rangan& Sharma 3. Considine's Handbook on Instrumentation 4. Atomic absorption and Emission Spectrophotometers, Ed Metcalfe 5. Industrial Instrumentation, D.P.Eckman

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE610	Animal Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	CO1: To elucidate the scope of Animal Biotechnology. CO2: To learn the different areas of Animal Biotechnology applications. CO3: To learn the basic technology in each area of Animal Biotechnology. CO4: To learn the future prospect of the Animal Biotechnology.						

Topics Covered	**Animl Cell culture:**History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions. Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization (8) **Technology – Present and future :** Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering (4). **In Vitro Fertilization and Embryo Transfer:** Basic knowledge on Fertilization and embryology, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA (4) **Stem cells:** Classification and types, Sources, Markers, Differentiation signals, application, IPSC, Cncer stem cells (4). **Gene Therapy:** Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system, Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vector system, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents (4) **Transgenic and Konck out Animals:** Methodology, Embryonic Stem Cell method, Microinjectionmethod, Retroviral vector method, Applications of transgenic animals **Recombinanat protein expression and purification:** Expression vectors for mammalian proteins, Cell (S cerevicea, P pasturis etc.) for large scale mammalian protein production, Post translational modification and purification.
Text Books, and/or reference material	Suggested Text Books: 1. Animal Cell Culture by John R.W. Masters; Oxford University Press Suggested Reference Books: 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts; Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

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

BTE611	Industrial Microbiology	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To interpretbasic concepts for the production of microbial products.fermentation and separation technology CO2: To learn about the different types of Bioreators and their use. CO3: To analyse the principles, and techniques for improving the yield and desired properties in via strain improvement strategies. CO4: They will be able to apply the knowledge related to processes, equipment for industrial purpose and solve the problems.						
Topics Covered	**Industrial Microbiology– BTE611** **Introduction to Fermentation Technology: 12** Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. Types of Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; Media sterilization,.Preparation of microbial inoculum for Industrial fermentations. **Commercial strain development: 12** Induced mutations, Over producing decontrolled mutants, Catabolic derepressed mutants; Genetically engineered strain; Protoplast fusion technique. Improvement of strain by Site directed mutagenesis and Protein engineering : Definition, methods and application. Improving microbial strain forproduction of Amino acids Lysine and nucleosides and nucleotidesforaroma.Methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. **Microbial processes for production of valuables 10** Introduction, on Microbial growth and its kinetics.Primary and secondary metabolites and their regulation. Microbial production of organic acids, antibiotics,alcohol, bakers yeast, Single cell protein (SCP); Vitamins.Organisms used,(wild and mutated). production method- process, recovery of products separation parameters , purification steps..Application . **Microbial Enzyme Technology: 10** Microbial process for production of enzymes.Commercial production of enzymes; amylases, proteases,cellulase.Enzyme Modification - site directedmutagenesis;Importance of Stability of enzymes;Enzyme stabilization by selection and protein engineering for T4 Lysozyme; Principles & techniques of immobilization of Enzymes, Application of immobilized enzyme in Industrial processes						

Text Books, and/or reference material	Suggested Text Books: 1. Industrial Microbiology, Casida L E 2. Biotechnology: A textbook of industrial microbiology: CruegerW ,Crueger A 3. Industrial Microbiology, Prescott & Dunn Suggested Reference Books: 1. Prescott's and Dunn's, A. Industrial Microbiology, 4th edition. CBS Publishers, New Dehli , India , 1987. 2. L.E. Cassida.Jr, Industrial Microbiology, New Age International Publisher 3. Atkinson.B and Marituna.F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ. Ltd. 4. Bailey &Olis, Biochemical Engineering Fundamentals, MGH. 5. Review papers from reputed international journals to convey the current progress .in this area.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE612	NUTRACEUTICAL AND NUTRIGENOMICS	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To establish the correlation between nutraceuticals with cell signaling pathway. CO2: To target nutraceuticals from different sources for prevention of disease. CO3: To understand the interaction between gut microbiota with functional food components and nutraceuticals and improvement of health. CO4: To formulate the concept of nutrient gene interaction for prevention of lifestyle related disorders.						

Topics Covered	Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals. **[8]** Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics and transcription factors. **[8]** Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds**. [5]** Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria **[7]** Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in Nutrigenomics **[12]**
Text Books, and/or reference material	Suggested Text Books: 1. Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput, Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John Shi , CRC Press 2. Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press Suggested Reference Books: 1. Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press 2. Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade 3. Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Haslr, Blackwell Publishing Professional

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

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

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

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

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

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

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

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

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

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

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC01 (Life Science), PHC01 (Physics), CYC01(Chemistry)	CT+MT+EA
Course Outcomes	● CO1: Acquire an idea about nanoscale phenomenon ● CO2: To learn about the basic investigation tools for the nanobiotechnology ● CO3: To learn about bottom up and top down synthesis of nanosystems ● CO4: to get comprehensive understanding of applications of nanotechnology in biology
Topics Covered	● Nanotechnology; introduction to miniaturization. (4) ● Iinvestigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. Investigation tools: lithography (8) ● Nanomaterials: organic and inorganic nanoparticles. Synthesis, assembly, and processing of nanostructures: phenomenon of self-assembly. (6) ● Molecular self-assembly and bottom up synthesis of nanomaterials. (6) ● Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6) ● Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6) ● Nanotoxicology. (4) ● Future Concepts in Nanobiotechnology. (2)
Text Books, and/or reference material	Suggested Text Books: 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. Suggested Reference Books : 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press

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

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

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 618	FOLDING, MISFOLDING AND DISEASES	PEL	3	0	0	3	3

BTC401- Molecular biology &rDNA Technology; BTC 303 Biochemistry & Enzyme Technology; BTC 301 Cell biology and genetics	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
	CT+MT+EA
Course Outcomes	● CO1: To acquire an understanding of the protein structure ● CO2: To learn about the principles of protein folding and misfolding ● CO3: To obtain a comprehensive idea of different diseases related to protein misfolding ● CO4: Development of cumulative understanding of protein folding, misfolding and diseases to find much-needed cure for the relevant conditions.
Topics Covered	Basic of protein misfolding related diseases. The hierarchical structure of the protein. Principles of protein stability and folding. (16) Protein misfolding and aggregation. Protein quality control: molecular chaperones, protein degradation, autophagy and aging. (12) Prion Diseases. Alzheimer's Disease. Parkinson's Disease. Huntington's Disease and other unstable repeat disorders. Amyotrophic lateral sclerosis and frontotemporal lobar degeneration. (14)
Text Books, and/or reference material	Suggested Text Books: 1. Fundamentals of Neurodegeneration and Protein Misfolding Disorders by Martin Beckerman, Springer 2. Introduction to Protein Structure by Carl IV Branden, Routledge Suggested Reference Books: 1. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding by Alan Fersht, W. H. Freeman.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE619	ENGINEERING RESISTANCE IN PLANTS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC502 (Cell & Tissue Culture of Animals & Plants)		CT+MT+EA					

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

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS651</td><td>MOLECULAR BIOLOGY AND rDNA TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the principle of isolation of nucleic acids through different techniques.
CO2: To understand the techniques used in manipulation of nucleic acids.
CO3: To develop expertise to apply the toolsof gene cloning and solve the problems associated with production of recombinant protein from genetically modified microorganisms.
CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results
CO5: To understand the basic hazards of working with nucleic acids and safety measures.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Isolation of genomic DNA
2. Quantification of DNA
3.Agarose Gel Electrophoresis of DNA
4. Isolation of RNA
5. Agarose Gel Electrophoresis of RNA
6. Isolation of plasmid – agarose gel electrophoresis (quantitation and purity test)
7. Restriction digestion of plasmid – agarose gel electrophoresis
8. Bacterial transformation using plasmid having antibiotic resistant marker and some other genetic markers.
9. Southern Blotting
10. PCR technique</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested text Books:</u>
<u>Suggetsed Reference Books:</u>
Sambrook et al., “Molecular Cloning” A Laboratory Manual</td></tr>
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<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS652</td><td>BIOINFORMATICS LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td colspan="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">Programming and Data Structure (CSC431)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: To acquire programming knowledge to analyze biological data
● CO2: To learn about different biological databases and retrieval of biological data in different file formats.
● CO3: To learn different bioinformatics softwares related to sequence, structure and phylogeny</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Bash programming (Linux commands) for data mining (3)
2. Handling Biological databases and sequence and structure retrieval (2)
3. Pairwise Sequence Alignment: BLAST tool and interpreting the results (1)
4. Multiple Sequence Alignment: Clustal, Muscle etc. (1)
5. Phylogenetics methods for phylogenetic tree constructions: Mega, Phylip (1)
6. C and Python scripts to analyse and interpret biological data (3)
7. Protein Structure and its visualization, structural alignment softwares: PyMOL, Rasmol, VMD (1)
8. Protein Structure prediction softwares: Modeller, I-Tasser, Psipred (1)
9. RNA related softwares: Vienna Package (1)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Suggested Text Books:
1. The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr.
2. Python Crash Course by Eric Matthews
Suggested Reference Books:
1. A Byte of Python by C.H. Swaroop
2. A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell</td></tr>
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<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS681</td><td>DATABASE MANAGEMENT SYSTEM LABORATORY</td><td>PCR</td><td></td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">1. Computer fundamentals, Data structures
2. Fundamentals of any computer programming languages</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand, appreciate and effectively explain the underlying concepts of database technologies
CO2. Design and implement a database schema for a given problem
CO3. Populate and query a database using SQL DML/DDL commands</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. SQL Queries
2. PL/SQL assignments</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Suggested Text Books:
SQL and PL/SQL by Evan Bayross.
Suggested Reference Books:</td></tr>
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SEVENTH SEMESTER

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	PRINCIPLES OF MANAGEMENT	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1:To make budding engineers aware of various management functions required for any organization CO2:To impart knowledge on various tools and techniques applied by the executives of an organization CO3:To make potential engineers aware of managerial function so that it would help for their professional career CO4:To impart knowledge on organizational activities operational and strategic both in nature C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science						
Topics Covered	**UNIT I:** Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization**(8)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7) **UNIT III:** Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8) **UNIT V:** Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)						

Text Books, and/or reference material	Suggested Text Books: ● Financial Management, 11th Edition, I M Pandey, Vikas Publishing House. ● Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India ● Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education ● Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India ● Operations Management, 7th edition (Quality control, Forecasting), Buffa&Sarin, Willey Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
BTE710	MOLECULAR PLANT PATHOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE), mid-term (MT) and end assessment (EA))					
BTC01		CE+MT+EA					
Course Outcomes	CO1: To understand molecular mechanisms of plant defense systems. CO2: To understand molecular mechanisms of pathogenesis. CO3: To have the idea to design strategies for protection of plants.						
Topics Covered	Introduction to molecular plant pathology [1] Plant diseases [2] Plant disease development and environment [2] Effects of pathogen on plant physiology [2] Biochemistry of plant defense reactions [5] Plant-pathogen interactions [5] Genetic regulation of resistance in host plants [5] Genetic regulation of virulence in pathogen [5] Mechanisms of host defense [5] Mechanisms of pathogenesis [5] Biotechnological approach for plant protection; genetically modified plants to protect against pathogens [5]						

Text Books, and/or reference material	Suggested Text Books: 1. Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. 2. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. Suggested Reference Books: 1. Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. 2. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer 3. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 711	CANCER BIOLOGY AND CELL SIGNALING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC301-Cell Biology and Genetics/BT-817- Cancer Biology		CT+MT+EA					
Course Outcomes	CO1: To understand the basic concepts of cancer biology and related cellular signalling CO2: To understand the development and causes of cancer. CO3: To understand the therapeutic aspects of cancer prevention CO4: To identify the target molecules that are associated with cancer so that the cancer preventive small molecule inhibitors/phytochemicals can be screened.						
Topics Covered	**Cancer Biology** Introduction to Cancer and Molecular basis of cancer [2] Mutation and DNA damage repair mechanism [2] Cell cycle [3] Oncogenes (tumor viruses) , Tumor suppressors [3] Epigenetics, non-coding RNAs and genome fluidity in cancer [4] Cancer and Stem Cells, Angiogenesis, Apoptosis [4] Cancer therapy, Future of Cancer research [3] **Cell Signaling related to cancer** Introduction to cellular signaling [3] Signaling molecules – (e.g. Hormones, Interferons and others) [3] Receptor-mediated signaling in cells [3] Role of different transcription factors and kinases (e.g. MAP kinases and other ser/thr kinases) [4]						

	Involvement of different signal transduction pathways during cancer initiation, progression and metastasis [5] Small molecule inhibitors of cancer [3]
Text Books, and/or reference material	Suggested Text Books: 1. Weinberg RA. The Biology of Cancer, 2nd Edition. Garland Science, 2013. 2. Cellular signal processing , 2nd Edition by Friedrich Marks, Ursula Klingmuller and Karin Muller-Decker, Garland Science Suggested ReferenceBooks: Selected reviews and primary scientific literature

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE712	FOOD BIOTECHNOLOGY	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation & increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant & nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.						
Topics Covered	**Food for health and wellness [2]** **Food Microbiology: [6]** Detection of microorganism in food – role of PCR, DNA CHIP, rapid methods for identification of microorganism in food, immunological methods, Bioassay, Biosensors- detection of toxin, heavy metal , pesticide and herbicides **Food preservation [10]** Pasteurization, sterilization, Canning, Irradiation, Dehydration, low temperature Food preservation, use of preservatives, **Food fermentation [8]** Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages , dairy product, non beverage product , use of genetic engineering techniques for improved quality product.						

	Genetically modified food **[6]** Fruit ripening, improvement of sweetness, flavor, starch, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Single cell protein, single cell oil, Spirulina, **Biotechnology in relation to food product and Food Safety (5+5)** Antioxidant, nutraceutical, Nutrigenomics Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series
Text Books, and/or reference material	Suggested Text Books: Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Suggested Reference Books: Fundamentals of Food Biotechnology by Lee

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE713	BIOPHARMACEUTICAL PROCESS DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To learn about the manufacturing process and facility design for biopharmaceutical products CO2: To acquire knowledge of detailed design of GMP compliant biopharma plant CO3: To study the design and optimization of downstream processes of therapeutic protein manufacture in a commercial set up CO4: To learn about technology transfer, regulation, validation and quality assurance of biopharma industry						

Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6] Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [12] Role of process development group and manufacturing group in biopharmaceutical process start up. [3] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [5] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [6]
Text Books, and/or reference material	Suggested Text Books: Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH Suggested Reference Books: Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE714	BIOENERGY	PEL	3	0	0	3	3

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

Course Outcomes	Learn about energy crisis, problems of fossil fuel use, global warming Learn about production of biological solid fuel. Learn about gaseous biofuel production like methane and hydrogen in detail. Learn about liquid biofuels Learn about benefits and deficiencies of biofuels, life cycle analysis
Topics Covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6] Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel. Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5] The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6] Jatropha cultivation, National hydrogen energy road map. [3]
Text Books, and/or reference material	Suggested Text Books. 1. Biofuels production, application and development. Alan Scragg, CABI. Suggested Reference Books:

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

BTE715	PROJECT ENGINEERING FOR BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To learn about detailed design of a manufacturing plant CO2: To learn about cleaning, sterilization, waste management and utilities of a biotechnology production plant CO3: To study about Planning, construction and commissioning of a biopharmaceutical manufacturing plant CO4: To learn about project management and financial aspects of the plant						
Topics Covered	Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments & their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods [6] Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and cleanability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. [6] Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) [6] Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. [6] Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. [6] Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. [6] Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. [3] Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. [3]						

Text Books, and/or reference material	Suggested Text Books: Bioprocess engineering: system, equipment and facilities, B K Lydersen, NAD'Elia, K M Nelson. Wiley Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley Suggested Reference Books: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 716	STRUCTURAL BIOLOGY	PEL	3	0	0	3	3
BTC401- Molecular biology &rDNA Technology and BT C303 Biochemistry & Enzyme Technology		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To acquire understanding of the basic building blocks of life CO2: To learn about the most common structural motifs found in protein and DNA CO3: To understand the atomic level interaction between the protein and DNA CO4: To learn how to determine protein structure						
Topics Covered	Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, folding and flexibility, DNA structures. (8) Structure, function and engineering - DNA recognition in prokaryotes by helix-turn-helix motifs. (4) DNA recognition by eukaryotic transcription factors, specific transcription factors (5) Enzyme catalysis with example of serine proteinases, membrane proteins, signal transduction, fibrous proteins (7) Recognition of foreign molecules by immune system, structure of spherical viruses (8) Prediction, engineering and design of protein structures, determination of protein structures (10)						
Text Books, and/or reference material	Suggested Text Books: 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge Suggested Reference Books: Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht						

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE717</td><td>ENVIRONMENTAL BIOTECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn about air pollution monitoring and control
CO2: To learn about waste water treatment processes along with analytical procedures
CO3: To study about solid waste management
CO4: To acquire knowledge on bioremediation of pollutants</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Air pollution control methods and equipment - Primary and secondary air pollutants, Effect of air pollutants on health, Control of gaseous and particulate pollutants, air pollution control equipments. 6
Water pollution: sampling and analysis - Sampling, BOD and COD analysis, Bacteriological measurements, Numerical problems 5
Water and waste water treatment processes - Overview of treatment principles. Primary treatment – screening, sedimentation, flotation, neutralization etc. 4
Secondary treatment - Activated sludge process, extended aeration, Trickling filter, Aerated lagoons, Waste stabilization ponds, Aquatic plant systems, UASB reactors. Design of a complete mix activated sludge process. 8
Biomethanation. Nitrification and denitrification operations. Phosphorus removal. Sludge treatment and disposal. Tertiary treatment. Membrane based treatment processes. 8
Solid waste management, Vermiculture, hazardous waste management 5
Specialized aspects - Bioremediation for recovery of metals, Xenobiotics, Degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, Phytoremediation. Reactors in bioremediation. 6</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books</u>:
Introduction to waste water treatment processes, Ramalho, Elsevier.
Environmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. &Greogia; PHI
Waste water treatment and disposal, Arceivala, Wiley
Environmental Biotechnology, Alan Scragg, Oxford University press
<u>Suggested Reference Books</u>:
Waste water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill
Industrial Water Pollution Control, Eckenfelder, McGraw Hill.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE718</td><td>PROTEOMICS AND PROTEIN ENGINEERING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC303 Biochemistry and Enzyme Technology;
BTC401 Molecular Biology and Recombinant DNA Technology;</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will acquire knowledge on protein structure and function and will be able to apply the understanding in designing strategies for proteomic analysis and protein engineering.
CO2: Students will be acquainted with tools and techniques for proteomic analysis and will be able to analyze proteomic data using databases.
CO3: Students will be acquainted with tools and techniques for protein engineering and will be able to apply them to solve problem related to protein function and efficiency.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to proteinstructure and function: Elementary ideas of bonding and structure, stereochemistry; spectroscopic techniques. Amino acid structure and properties to 3D structure of protein. Basic principles of protein folding anddynamics. Protein sequence andevolution. [10]
Proteomics and its application: Chromatography principles. Analytical protein and peptide Separation, Protein Digestion Techniques, Mass Spectrometers for protein and peptide analysis, protein identification by peptide Mass fingerprinting. Mining proteomes, protein expression profiling, identifying protein-protein interactions and protein complexes, Mapping protein modifications. [16]
Protein Engineering: Proteins design and engineering, Random, site directed mutagenesis; Strategies to alter catalytic efficiency; structure prediction and odelling proteins; Molecular graphics in protein engineering; Dynamics and mechanics; Drug-protein interactions and Design; applications of engineered proteins. [16]</td></tr>
</table>

Text Books, and/or reference material	Suggested Text Books: R.M. Twyman; Principles of Proteomics, Bioscientific Publishers. Biotechnology, 2nd Edition 2015. David Clark and Nanette Pazdernik. Academic Cell. Suggested Reference Books: B.Alberts,D.Bray, J.Lewis et al, Molecular Biology of the Cell, Garland Pub. N.Y 1983. Richard J. Simpson, Proteins and Proteomics, I.K. International Pvt Ltd. Daniel C. Liebler, Introduction to Proteomics: Tools for the New Biology, Humana Press.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE719	MOLECULAR MODELLING &DRUG DESIGN	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Biochemistry and Enzyme Technology, Bioinformatics		CT+MT+EA					
Course Outcomes		CO1: To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. CO2: To learn the fundamental concepts of structure-activity relationships CO3: To learn design of novel, biologically active compounds and Toelucidate the mechanism of action of drugs					
Topics Covered		Introduction to molecular Simulation Techniques (5) Quantum chemistry for Modeling of small molecules (5) Molecular Dynamics Methods- Molecular Dynamics of rigid non linear poly atomic molecules in ensembles, Structural information from M.D. (5) Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable forcefields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design: Principles of receptor based de novo ligand design. Rigid body molecular Docking. (7)					

Text Books, and/or reference material	Suggested Text Books: A R Leach-Molecular Modelling,. Principles and application 2nd edition–Prentice Hall. Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London Suggested Reference Books: G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley Scolnick.J.(2001) Drug Discovery and Design .Academic Press, London N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design.* Academic Press, San Diego, 1996.

Department of Biotechnology							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE720	NANOTHERAPEUTICS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					

Course Outcomes	CO1:To understand the role of the small molecules in the drug delivery system. CO2: To learn the fundamentals and principles of nanotechnologies in drug release system. CO3: To understand methods of nanotechnology in point of care diagnosis. CO4: To understand the basic mechanism of nanotherapeutics of tumours.
Topics Covered	**UNIT -I NANOPHARMACEUTICALS** **Nano-biotechnology for Drug Discovery** -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules . 5 Dendrimers, Nanobodies, Nanospheres-Nanotubes –Nano-cochleates.-Nano-molecular Valves for Controlled Drug Release –Nano-motors for Drug Delivery. 6 **UNIT - II ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES** **Development of nano medicines** – Nano Shells – Nano pores – Tectodendrimers – Nanoparticle drug system. Biomedical nanoparticles –Liposome's Different types of drug loading – Drug release – Biodegradable polymers. 5 Applications Nano biotechnologies for Single-Molecule Detection -Protease-Activated Quantum Dot Probes. 3 Nanotechnology for Point-of-Care Diagnostics –Nano diagnostics for the Battle Field – Nano diagnostics for Integrating Diagnostics with Therapeutics. 4 **UNIT – III APPLICATION IN CANCER THERAPY & NANOMEDICINE**

	Introduction and Rationale for Nanotechnology in Cancer Therapy -- Diagnostic approach by nano-sensing. 3 Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications. 5 Pharmacokinetics of Nano-carrier-Mediated Drug and Gene Delivery. 4
Text Books, and/or reference material	Suggested Text Books: 1. Kewal K. Jain, The Handbook of Nano-medicine Humana Press, (2008). Suggested Reference Books**:** Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005). Robert A. Freitas Jr., —Nano-medicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).

Department of Biotechnology							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE721	BIOMATERIALS	PEL	3	0	0	3	3
BT C303 Biochemistry & Enzyme Technology, CYC01 Chemistry		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: Classify the biomaterials and recognize their production and properties. CO2: Explain the application areas of biomaterials CO3: To realize the important basic properties and requirements for biomaterials CO4: Recognize the importance of relationships between living tissues and biomaterials						
Topics Covered	Definition of biomaterials – biologically derived materials or materials compatible with biology. **(2)** Common biomaterials: some proteins, many carbohydrates and some specialized polymers. **(4)** Collagen (protein in bone and connective tissues): Structure production and its use. **(3)** Fibroin (protein in silk): Production and its use. **(2)** Production of these proteins by conventional cloning methods. **(3)** Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; **(8)** Biopolymers: Synthesis from a simple biological monomer (eghyaluronate polymers); Dextrans (used in chromatography columns); Rubberllike materials produced by bacteria and fungi (Polyhydroxybutyrate PHB), Poly-caprolactone (PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligeneseutrophus; Biodegradable polymers **(8)**						

	Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. **(8)** Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems. **(4)**
Text Books, and/or reference material	Suggested Text Books: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Suggested Reference book: 1. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

Department of Biotechnology							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE722	VACCINE TECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC402 Immunology		CT+MT+EA					
Course Outcomes	CO1: To understand the factors that influence vaccine design and development CO2: To understand how research based discovery has driven vaccine development CO3: To know about the different types of vaccines CO4: To learn about the quality control and regulation in the vaccine production CO5: To understand the importance of vaccination as a public health strategy						
Topics Covered	History of vaccine development- Importance of vaccines (2) Immunological response to vaccines (2) Vaccine design and development: Epitope identification; Vaccine efficacy, Adjuvants (6) Different types of vaccines: Inactivated toxins, Inactivated whole bacteria or viruses, Live attenuated bacteria or viruses; Subunit vaccines, Polysaccharide vaccines, Conjugated vaccines ; Recombinant DNA vaccines, Edible vaccines, Virus like particles(8) Next-generation vaccines: Human Immunome project; Human antibodies as vaccines (4) Production techniques used for vaccines (4) Storage and preservation of vaccines (4) Delivery methods: microspheres, nanoparticles; ISCOMS and immune modulators (6) Regulatory issues in vaccine production: OIE guidelines for production and seed lot management; Manufacturing recommendation; Final product release tests (5) Vaccine safety-the debate (1)						

Text Books, and/or reference material	Suggested Text Books: New Vaccine Technologies: Ronald W. Ellis (Landes Bioscience), 2001. Vaccines: Stanley A. Plotkin, Walter A. Orenstein, Paul A. Offit(Elsevier), 6th Edition Suggested Reference Books: Medical Microbiology : Samuel Baron , 4th Edition (University of Texas) Advances in Vaccine Technology and Delivery: Cheryl Barton, Espicom Business Intelligence. "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries": Noel Mowat, Daya books.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE723	STEM CELL BIOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Cell Biology, Biochemistry, Genetics, Molecular Biology		CT+MT+EA					
Course Outcomes	CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signalling molecules and the use of such factors for tissue production in-vitro. CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodelling to correct these changes CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy. CO4: To understand the recent advances on application the regenerative therapy from well characterzied case studies.						

Topics Covered	An Introduction to Stem Cells (2) Adult Stem Cells (1) Embryonic Stem Cells (1) Induced Pluripotent Stem Cells (1) Hematopoietic Stem Cells (1) Messenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) Molecular and Cellular Bases of Organ Development (6) Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals (4) Molecular Bases of degenerative disease (1) . Therapeutic Uses of Stem Cells with examples (2) . In vivo Regeneration of Tissues by Cell Transplantation (2) . IPS Cells as Experimental Models of Neurodegenrative Disorders: use of them as disease modelling platform, novel drug testing and tissue renerarative therapy and implantation studies(2) . Studies of Patients Treated with Stem Cells, The modalities of treatment, Preperation of cells/tissues/scaffolds and Trnasplantation procedure (3) . Tissue Regeneration Driven by Growth Hormones (2) . Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs (8) . Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)
Text Books, and/or reference material	Suggested Text Books: Stem Cells, Tissue Engineering And Regenerative Medicine By: David Warburton 1st Edition. Principles of Regenerative Medicine by Anthony Atala Robert Lanza Tony Mikos Robert Nerem , 3rd Edition. Translational Regenerative Medicine by Anthony Atala and Julie G. Allickson Suggested Reference Books: The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G. Tenth edition. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, IstEdtion.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE724	APPLICATIONS OF MOLECULAR CLONING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC401 (Molecular Biology &rDNA Technology)		CT+MT+EA					

Course Outcomes	CO1: To understand the fundamentals of molecular cloning. CO2: To learn the basic methods of molecular cloning. CO3:To gain knowledge about the potential application aspects of molecular cloning. CO4: To build-up a bridging concept for extension of theoretical knowledge to practical applications of molecular cloning.
Topics Covered	**Module 1: Basic principles of molecular cloning** Why gene cloning and DNA analysis are important (2) Vectors for gene cloning (2) Purification of DNA from living cells (2) Manipulation of purified DNA (3) Introduction of DNA into living cells (3) Cloning vectors for prokaryotes (3) Cloning vectors for eukaryotes (3) How to obtain a clone of a specific gene (2) Other molecular techniques (2) **Module 2: Applications of molecular cloning in research** Sequencing genes & genomes (3) Studying gene expression & function (3) Studying genomes (4) **Module 3: Applications of molecular cloning in biotechnology** Production of protein from cloned genes (2) Gene cloning & DNA analysis in medicine (3) Gene cloning & DNA analysis in agriculture (3) Gene cloning & DNA analysis in forensic science &environment (2)
Text Books, and/or reference material	Suggested Text Books**:** T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Seventh Edition, Wiley Blackwell. Suggested Reference Books: Sandy B. Primrose, Richard Twyman& Bob Old, Principles of gene manipulation primrose: An introduction to genetic engineering, Sixth Edition, Blackwell Science

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	GENETIC ENGINEERING	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes	**CO1:** Students will acquire basic understanding of molecules of life and their basic chemistry. **CO2:** Students will acquire knowledge of how genetic material stores programs of life and how that information is retrieved. **CO3:** Students will acquire knowledge of basic tools of genetic engineering and their applications. **CO4:** Students will be able to apply the acquired knowledge in understanding and solving biotechnology issues surrounding us.
Topics Covered	Structures of macromolecules such as Carbohydrates, Proteins, Enzymes, Lipids and Nucleic Acids. [10] Basics of cell biology, prokaryotes vs. eukaryotes, sub-cellular structures, their organization and functions. [10] Central Dogma of molecular biology, DNA Replication, Transcription, Reverse Transcription, Translation. [10] Basic tools of nucleic acid manipulation. Methods of genetic engineering; Genetic engineering of microbes, plants and animals.[12]
Text Books, and/or reference material	Suggested Text Books: Essential Cell Biology, 4th Edition, Albertset. al. Biotechnology.2nd Edition, 2015. David Clark and Nanette Pazdernik.Academic Cell. Cecie Starr, Christine A. Evers, Lisa Starr. Biology: Today and tomorrow with physiology. Suggested Reference Books: Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, Molecular Biology of the Cell, Garland Science. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT1002	Bioprocess Engineering	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: Strengthening of basic concepts of stoichiometry, kinetics, heat and mass transfer CO2: In depth learning of reactor design and operation for free and immobilized cells CO3: Learning of detailed processes of large scale mammalian cell and plant cell culture						

Topics Covered	Recapitulation: Stoichiometry of Growth and Product formation. Heat transfer for biochemical processes. Kinetics of Growth and Product formation in Batch, Continuous and Fed batch systems. 12 Media Sterilization and Air Sterilization. Design of Stirred Tank Bioreactors. 4 Mass transfer studies in stirred tank reactor and in free and immobilized cell bioreactors. 5 Design of Immobilized biocatalytic reactor, perfusion reactor, membrane reactor, Hollow fibre reactor, airlift reactor. Reactors for solid state fermentation. 5 Large scale mammalian cell culture – non perfused attachment system, fed-batch and perfusion for cell cultivation, suspension culture, microcarrier culture system, microencapsulation, large scale stirred tank and air lift reactors for cultivation of animal cell. Discussion on single use technologies. 10 Plant cell bioreactors – their design and operation. 3 Scale up, Instrumentation and Control of Bioreactors. 3
Text Books, and/or reference material	**Books** Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Bioreactors: Analysis & Design, Tapobrata Panda, McGraw Hill Doran PM, '*Bioprocess Engineering Principles*', Academic Press **Reference:** Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. International Cell Culture Technology for Pharmaceutical and Cell-Based Therapies, Sadettin Ozturk, Wei-Shou Hu, CRC Bioprocess Engineering: Kinetics, Biosystems, sustainability and reactor design by Shijie Liu, Elsvier Publisher.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of Contact Hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC701	Modern Techniques in Biotechnology	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01, BTC401		CT+MT+EA					
Course Outcomes		CO1: To get an exposure to the current status of genomic research and to develop an idea about several applications of genomics with respect to health and well-being. CO2: To gain knowledge about advanced methods needed to study macromolecular structures and functions. CO3: To gain exposure to tools involved in manipulation of nucleic acids; advanced genetic engineering and molecular biology tools as well as advanced microscopy and immunological techniques.					

Topics Covered	**Introduction to Genomics:** Importance of genomics; Sequencing of genomes; Assembly of genome sequences; The human genome project; Locating the genes in the genome; Determination of gene functions; Structural, comparative and functional genomics; Lessons from various prokaryotic and eukaryotic genomes; Comparative genomics in evolution and medicine; Genomic variations; Transcriptomes: measurement of gene expression; Genome and genome analysis; Bridging genomics to proteomics; Metagenomics. (14 classes) **Techniques for studying Macromolecular Structure.** Ultra centrifugation Sedimentation velocity and equilibrium determination of molecular weights; Electron microscopy; UV Visible Spectroscopy; Fluorescence Spectroscopy; Circular Dichroism Spectroscopy; Determination of protein 3D structure by Nuclear Magnetic Resonance spectroscopy; Determination of protein sequence by mass spectrometry. (14 classes) **PCR Techniques :**Multiplex, nested; reverse transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection. (3 classes) **Genome Editing Tools:** Gene silencing: introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy. Restriction Enzymes; Zinc finger nucleases, TALENs, CRISPR-Cas9hybridization techniques. (4 classes) **Protein-DNA Interaction:** Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase foot printing; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display, FRET (4 classes) **Microscopy and Immunological Techniques**: Application of following microscopes and microscopy techniques: Light and phase contrast; Fluorescence; Confocal; FRAP; TIRF; Electron (TEM and SEM); Electron tunnelling and Atomic Force Microscopy; Antibody generation, Flow cytometry (3 classes).
Text Books, and/or reference material	Suggested Text Books: 1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications. 2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Branden, Carl Ivar & Tooze, John (1999). Introduction to Protein Structure: 2nd Edition. Routledge, Taylor Francis Group: Garland Publishing. Suggested Reference Books: 1. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 2. Fersht, Alan. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding. 3 Relevant review articles/research papers/handouts/technical literature of companies provided in the course.

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<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS751</td><td>BIOSEPARATION AND BIOCHEMICAL ANALYSIS LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous assessment (CA), mid-term (MT) and end-term examination (ET))</td></tr>
<tr><td colspan="3">Bioseparation& Biochemical Analysis (BTC 503)</td><td colspan="5">CA+ET</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To determine the specific cake resistance & filter medium resistance by constant pressure filtration/pressure-time variation in constant rate filtration
CO2: To prepare a cell-free extract by sonication/homogenization and identify a specific protein therein by Western Analysis
CO3: To learn the technique of salt precipitation of a protein and subsequent dialysis for removal of the salt and to get an idea of other equipment for concentrating a protein
CO4:To construct a binodial diagram and study the extraction of a protein in an aqueous two-phase system
CO5:To separate out a protein from a mixture by gel filtration/ion exchange chromatography and to concentrate a protein by ultrafiltration
CO6: To extract and estimate biomolecules such as lipids, DNA, & RNA</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Filtration (constant pressure filtration)
Preparation of cell-free extracts from cultured cells
3. Salt precipitation of protein and Dialysis
4. Extraction and estimation of total lipid content
5. Separation/concentration of proteins by Ultrafiltration.
6. Aqueous two phase extraction (binodial diagram)
7. Separation of proteins by gel permeation/ion-exchange chromatography
8. Identification of a specific protein present in the cell-free extract by Western Analysis
9. Determination of DNA and RNA concentration by UV absorption
10. Demonstration of lyophilisation & Rotary vacuum evaporation</td></tr>
</table>

Text Books, and/or reference material	Suggested Text Books: Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press Geankoplis, Transport Processes & Unit operations, PHI. Suggested Reference Books: Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 Shuler & Kargi, Bio-process Engg. PHI Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS752	CELL & TISSUE CULTURE LABORATORY	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
BTC01 Life Science BTC301 Cell Biology and Genetics BTC 502 Cell and Tissue Culture	CT+EA

Course Outcomes	CO1: Students will be acquainted with basic plant tissue culture techniques. CO2: Students will be acquainted in basic animal cell culture techniques. CO3: Students will attain knowledge of application of cell and tissue culture techniques in academic and industrial laboratories. CO4: Students will have knowledge of biosafety and ethical issues related to cell and tissue culture.
Topics Covered	**Plant Tissue Culture** Preparation and sterilization of plant tissue culture media. Preparation of explants. Callus induction in rice. Regeneration of rice callus tissue. Rooting of regnerants in rice. **Animal Cell Culture** Sterilization Techniques, Preparation of Media & Preparation of Sera Primary Cell Culture Preparation of established Cell lines Cell Counting and Viability . Staining of Animal Cells & Preservation of Cells
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: 1. Laboratory manual

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 753	BIOCHEMICAL REACTION ENGINEERING LABORATORY	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+EA					
Course Outcomes	To learn the experimental protocol of microbial growth and inhibition kinetics in a batch process To study substrate degradation, cell growth and product formation with immobilized cells in plug flow bioreactors. To learn about functions of a fermenter To study non-ideality in a plug flow reactor						
Topics Covered	1. Microbial cell growth kinetics 2. Microbial cell inhibition kinetics 3. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous packed bed reactor. 4. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous fluidized bed reactor. 5. Function of bioreactor- a) calibration of DO electrode. B) Calibration of pH electrode. 6. RTD studies in a packed bed reactor						
Text Books, and/or reference material	Suggested text Books: Suggested Reference Books: 1. Laboratory manual						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 754	VOCATIONAL TRAINING / SUMMER INTERNSHIP AND SEMINAR	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NA		EA					

Course Outcomes	CO1: To learn literature mining and acquire knowledge of presenting data in a proper format CO2: To enhance the communication skills of students CO3: Enable the students to face various kinds of audiences and develop self-confidence CO4: To learn application of ethical principles in various fields of research
Topics Covered	Each student is allotted a slot where he/she presents a scientific topic (related to the summer training they did in the previous semester)
Text Books, and/or reference material	Suggested Text Books: N.A. Suggested Reference Books:

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS755	PROJECT-I	PCR	0	0	3	3	1

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
All the Program Core subjects	CT+EA
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. Students are required to familiarize themselves with the literature review and scientific techniques and skills.
Text Books, and/or reference material	Suggested text Books: Suggested Reference Books**:** Related research papers.

EIGHTH SEMESTER

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO840</td><td>INDUSTRIAL BIOTECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Life science</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1- To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results
CO-2 Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes
CO-3 .Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques
CO-4 Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation
CO-5 Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT 1 CELL CULTIVATION ,GROWTH KINETICS -- 10 Hrs
Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals..
UNIT 2-MEDIA PREPARATIONand STERILIZATION 10 Hrs
Sterilization: basic concepts in sterilization insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter
UNIT 3- BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs
Purpose and importance of bioreactor, Parts of fermenter and types ;Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility'Operational modes of bioreactor: batch, semi-batch/fedbatch, continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor.</td></tr>
</table>

	UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and A PPLICATIONS -10Hour Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases). Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.
Text Books, and/or reference material	Suggested Text Books: 1. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011. Suggested Reference Books: 1. Ashok Pandey et al., "Enzyme Technology", Springer Publisher, 2006. 2. Nielsen et al., "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), "Downstream Processing of Proteins: Methods and Protocols", Humana Press, 2000. 4. Satinder Ahuja, "Handbook of Bioseparations", Vol 2, Academic Press, 1st Ed., 2000.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO850	MEDICAL BIOTECHNOLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence. CO2: Able to analyze the key features therapeutics and drugs in current scenario. CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals. CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.						

Topics Covered	**Microbial pathogenesis:** Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics. **Diagnosis of Infectious diseases**–Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy. **Drug Design and Drug delivery system :** Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques . New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics **Molecular Medicine:** Antibodies and vaccines-Therapeutic production of antibodies different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection . **Cell and tissue therapy** – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery **Clinical Toxicology**, **Clinical Research Governance and Ethics:** Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation& drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. . International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.
Text Books, and/or reference material	Suggested Text Books: Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA Suggested Reference Books: Pharmaceutical Biotechnology ; Sambhamurthy & Kar , NewAge Publishers Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London V. Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT2001</td><td>Genomics, Proteomics and Bioinformatics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC01, BTC401</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: In depth understanding of genomes, transcriptomes and proteomes to address relevant problems.
CO2: Learning bioinformatics to analyse genomes, transcriptomes and proteomes.
CO3: Development of comprehensive understanding of “Omes& Omics” to solve the existing problems of the society.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to genomics; Importance of genomics; (2)
Sequencing of genomes; Assembly of genome sequences; (2)
The human genome project; (2)
Locating the genes in the genome; (2)
Determination of gene functions; (3)
Structural, comparative and functional genomics; (2)
Lessons from various prokaryotic and eukaryotic genomes; (3)
Comparative genomics in evolution and medicine; Genomic variations. (2)
Introduction to proteomics: (1)
Expression proteomics, Functional proteomics, Structural proteomics; (2)
Two-dimensional gel electrophoresis (2-DGE); Sample Preparation; Isoelectric focusing (IEF); (3)
Equilibration of the IPG strip, the second dimension and detection of proteins on the 2-DGE gel; (2)
Introduction to mass spectrometry; Mass spectrometry (MS) - based methods of protein identification: (3)
MALDI-MS, ESI-MS; (3)
Analysis of phosphoproteins by MS; Glycobiology and proteomics; (2)
Protein microarrays; Protein 3D structures; (2)
Protein interaction networks; Measuring proteins. (2)
Introduction to bioinformatics; (3)
Data acquisition; Databases and data retrieval; (3)
Searching sequence database; Multiple sequence alignment, (5)
phylogenetics and sequence annotation; (3)
Structural informatics; (4)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. S. B. Primrose and R. M. Twyman; Principles of Genome Analysis 2. A. M. Campbell and L. J. Heyer; Discovering Genomics, Proteomics & Bioinformatics; Pearson ducation; Second Edition. 3. T. A. Brown; Genomes; Wiley-Liss; Third Edition. Mount "Bioinformatics" Cold Spring Harbour 4. Arthur Lesk "Introduction to Bioinformatics" 5. Bioinformatics Sequences and Genome Analysis, 2nd edition 2004 by David W. Mount, CBS Publishers and Distributors. 6. Daniel C. Liebler; Introduction to Proteomics: Tools for the New Biology; Humana Press. 7. Richard Twyman; Principles of Proteomics; 2nd edition; Garland Science. Reference Books: S. B. Primrose and R. M. Twyman; Genomics: Applications in Human Biology Bioinformatics. (A.D.Baxevanis&B.F.F.Ouellette, eds.) Wiley Interscience, 1998.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT2053	**Omics and Bioinformatics Laboratory**	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Genomics, Proteomics & Bioinformatics		CT+EA					
Course Outcomes	CO1: To acquire knowledge of most important bioinformatics databases and learn text- and sequence-based searches to retrieve biological data in different file formats. CO2: Understanding pairwise and multiple sequence alignment using various softwares. CO3: Perform phylogenetic analysis to understand evolutionary relationships. CO4: To learn prediction of secondary and tertiary structures of protein and RNA Sequences						
Topics Covered	1. Introduction and use of various sequence and structure databases. 2. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, UniProt. 3. Pairwise Sequence Alignment: BLAST tool and interpreting the results 4. Multiple Sequence Alignment: Clustal, Muscleetc 5. Phylogeneticanalysisofproteinandnucleotidesequencesandphylogenetictree constructions using softwares like Mega, Phylip 6. Use of different protein family databases (SCOP,CATH). 7. Visualization of protein structures using Rasmol and PyMol.						

	8.Aligning protein structures. 9.Secondary structure prediction of proteins using DSSP, Pispred. 10.Homology modelling of proteins. 11.Using RNA structure prediction tools.
Text Books, and/or reference material	Text Books: The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr. Python Crash Course by Eric Matthews Reference Books: A Byte of Python by C.H. Swaroop A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS855	Project-II	PCR	0	0	6	6	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.						
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. Students are required to familiarize themselves with the literature review and scientific techniques and skills.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Related research papers.						

NINTH SEMESTER

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT 1051	**Bioprocess Engineering Laboratory**	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering							
Course Outcomes	**CO1**: To study the growth kinetics of E.coli and Saccharomyces cerevisiae in shake flasks and bioreactor **CO2:** To study the substrate utilization kinetics in a fermentation system **CO3:** To study the **S**terilization of a Bioreactor **CO4:** To determine Volumetric Oxygen Transfer Coefficient (K_La) in a Bioreactor **CO5:**To estimate Residence Time Distribution (RTD) in a Bioreactor **CO6:** To determine the correlation of Mixing Time with Reynold's Number in a fermentation system						
Topics Covered	1. Microbial Growth Kinetics 2. Determination Reducindg Sugar (Glucose) by Dinitrosalicylic acid (DNS) method 3. Media Sterilization and Air Sterilization 4. Aeration and Agitation in Bioreactors 5. Non ideal Flow in Bioreactors 6. Concept of Mixing Time determination						
Text Books, and/or reference material	Text Books: Reference Books: Mukhopadhyay S.N 2007. Experimental Process Biotechnology Protocols New Delhi Viva Books						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT3055	Major Project-I	PCR	0	0	22	22	11
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		NA					

Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.
Topics Covered	Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. Students are required to familiarize themselves with the literature review and scientific techniques and skills.
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books: Related Research papers

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT3056	Major Project Seminar- I	PCR	0	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		NA					
Course Outcomes		CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.					
Topics Covered		Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.					
Text Books, and/or reference material		Suggested Text Books: Suggested Reference Books:					

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT4055	Major Thesis Project - II	PCR	0	0	22	22	11
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.						
Topics Covered	Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:** Related research papers.						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT4056	Major Project Seminar-II & Viva Voce	PCR	0	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
All the Program Core subjects		EA					

Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.
Topics Covered	Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:** Related research papers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT4057	Comprehensive VIVA VOCE	PCR	0	0	0	0	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NA		EA					
Course Outcomes	**CO1:** To prepare the students to face future interviews. **CO2:** To develop logical thinking skills in the students.						
Topics Covered	1. All the topics taught in core courses. 2. Topics taught in the elective courses.						
Text Books, and/or reference material	Suggested Text Books: Suggested Reference Books**:**						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9031</td><td>Human Molecular Genetics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Genetics and Molecular Biology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">1. Learn about classical human genetics.
2. Learn about Mutation and diseases.
3. Learn about genetics of Neoplasia.
4. Learn about genomic imprinting and human disease
5. Learn about X-inactivation and DNA methylation.
6. Learn about gene mapping and positional cloning.
7. Learn about genetics of behavioral disorders
8. Learn about pharmacogenetics and biochemical genetics.
9. Learn about animal models in human genetics
10. Learn about methods used for diagnosis and detection of gene mutations</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1.Simple Mendelian traits.
Loss-of-function mutations; Gain-of-function mutations; Gene interactions;Dynamic mutations.
3.Genetics of neoplasia.
4.Genomic imprinting and human disease.
5. X-inactivation and DNA methylation
6. Gene mapping and positional cloning etics of behavioral disorders. Maco-genetics and biochemical genetics. mal models in human genetics. methods used for diagnosis and detection of gene mutations.</td></tr>
<tr><td>Text/ References</td><td colspan="7">1. Human Molecular Genetics : Tom Strachan and Andrew P Read
2. Thompson and Thompson Genetics in Medicine
3. An Introduction to Human Molecular Genetics: Jack J. Pasternak 4.Molecular Biology of the Gene: James D Watson
5. Genes IX: Benjamin Lewin
6. Concept of Genetics: Klug, Cummings and Spencer
7. Molecular Cell Biology: James E. Darnell
8. Molecular Biology of Cancer: Pecorino</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9032</td><td>Cancer Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Genetics and Molecular Biology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">1. Learn about classification of cancer, types and phenotypic characteristics.
2. Learn about DNA polymerase and DNA damage repairing mechanisms.
3. Learn about differentiation and apoptosis, Biology of metastasis, Carcinogenesis, Cancer genetics
4. Learn about Oncogenes and Tumor suppressor genes
5. Learn about Growth factors and signal transduction
6. Learn about Cell cycle regulation and check point.
7. Host tumor interactions, Gene rearrangements, detecting oncogene abnormalities in clinical specimens
8. Principles of chemotherapy, Concepts in cancer therapy - Mechanisms of cytotoxic drug action, Cancer Immunotherapy</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Phenotypic characteristics of cancer cells
2. DNA replication and Repair mechanisms
3. Role of differentiation and apoptosis, Biology of metastasis, Carcinogenesis, Cancer genetics
4. Oncogenes ,Tumor suppressor genes
5. Growth factors and signal transduction 6.Cell cycle regulation and check point.</td></tr>
<tr><td></td><td colspan="7">7. Host tumor interactions, Gene rearrangements, detecting oncogene abnormalities in clinical specimens
8. Principles of chemotherapy, Concepts in cancer therapy - Mechanisms of cytotoxic drug action, Cancer Immunotherapy.</td></tr>
<tr><td>Text/ References</td><td colspan="7">1. The Biology of Cancer: Robert Weinberg
2. Principles of Cancer Biology: LJKleinsmith
3. Cancer: A Beginner's Guide (Beginner's Guides): Paul Scotting 4.Molecular Biology of the Gene: James D Watson
5. Genes IX: Benjamin Lewin
6. Concept of Genetics: Klug, Cummings and Spencer
7. Molecular Cell Biology: James E. Darnell
8. Molecular Biology of Cancer: Pecorino</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9033</td><td>Signal Transduction</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="5">Course Assessment methods (Continuous assessment (CA) and end-
term examination (ET))</td></tr>
<tr><td colspan="2">Molecular Biology, Biochemistry, Cell biology and
Genetics</td><td colspan="5">CA+ET</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Acquire an understanding on fundamental components of signal transduction processes.
CO2: Acquire an understanding on various signaling steps in different physiological and developmental processes of bacteria, plants and animals.
CO3: To be able to design experiments to investigate new signaling pathways and regulation of gene expression.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Bacterial two-component regulatory systems (2)
Ligands, Receptors, Second messengers and Effectors (3) Carriers and channels of membrane (1)
G protein-coupled signal transmission (3) Protein tyrosine kinase (2)
Ras/MAP Kinase pathways (2) Transcription factors and regulators (3)
Chromatin remodeling (2)
Ethylene signaling (1)
Light perception and photoreceptors (2)</td></tr>
<tr><td></td><td colspan="6">Signal transducers and master regulators (3) Photomorphogenesis (2)
Transcriptional networks of seedling development (2) Light regulated gene expression (2)
Identification of novel signaling molecules (2) Functional characterization of new components (2)
Cross talks among various signaling pathways (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
Lewin’s Genes X by J.E. Krebs, E.S. Goldstein and S.T. Likpatrick
Research Articles on the said topics (usually given to the students)</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9034</td><td>Molecular Cell Signaling</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Cell Biology, Molecular Biology and Biochemistry</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the concepts of molecular signaling of cells which regulate its function.
CO2: To understand the deregulation of these pathways leading to functional defects at cellular and molecular level.
CO3: To identify the molecules than can be targeted therapeutically for the treatment of human diseases at cellular and molecular level.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Introduction of cellular signaling [4]
• Signaling molecules – Interferons, Interleukins and others [4]
• Receptor-mediated signaling in cells, Receptor associated and non-receptor tyrosine kinases and their involvement in different signal transduction pathways [5]
• Role of different transcription factors and kinases (MAP kinases and other ser/thr kinases) [7]
• Activation of various signalling pathways (Jak-Stat, MAPK, PI3K-Akt, NF-kB etc.) in different cells by extracellular stimuli [10]
• Involvement of signal transduction pathways in many important cellular processes like
Cell migration, cancer, angiogenesis etc. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
Molecular Biology of the Cellby Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.6th Edition, 2014.Garland Science. olecular Cell Biologyby Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger,
Matthew P. Scott, Anthony Bretscher, HiddePloegh, Paul Matsudaira. 8th edition, 2016.</td></tr>
<tr><td></td><td colspan="7">Publisher: WH Freeman. Reference Books:
1. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp. 6th Edition, 2010. Wiley. Essential Immunology, Roitt, I.M., 9th Ed. (1997), Blackwell Scientific, Oxford, UK
2. Immunology, Kuby, J. 3rd Ed. (1997), Freeman, W.H,Oxford,UK
3. Weir, Immunology, 8th ed, W.B. Saunders& Co.
4. K.A. Abbas, Immunology, 4th ed, W.B. Saunders& Co.
5. Relevant publications from many peer-reviewed journals.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9035</td><td>Food Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Bioseparation Technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO 1: To understand the concept of metabolic Engineering in food and apply it to increase the quality and productivity of food products
CO-2: To increase the efficiency of enzyme by protein engineering.
CO-3: To formulate associations between specific nutrients and genetic factors and to study how a food/food ingredient influence gene expression.
CO-4: To learn the concept of nutratceuticalsand help in the prevention of lifestyle related disorders.
CO-5: To study the application of nutratceutical in food based system and to develop delivery strategies for the nutraceutical.
CO-6: To learn about heat transfer, mass transfer and reaction kinetics in foods
CO-7: To learn about details of thermal processing of foods, dehydration operations and filtration operations art commercial level
CO-8: Studies on Food quality management and concept of HACCP CO-9: Studies on design of a food processing plant</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Food Biotechnology –
Food Microbiology- Metabolic Engineering of Bacteria for food ingredients, Metabolic engineering of Saccharomyces cerevisae (4)
Biotechnological Modifications of S. cerevisae and its effect in wine production, genetic Engineering of baker’s yeast, [2]
Recombinant Lactic Acid Bacteria [1]
Plant and Animal Food applications and functional food- Introduction to Nutraceutical and Nutigenomics, Probiotics, Bioavailability and delivery of nutraceuticals using nanotechnology Food and food component preventing cancer, Antiobesity effect of Allenic carotenoid, fucoxanthin, Encapsulation of probiotic bacteria, Antioxidant [10]
Improvement in Food Quality- Enzymes & Recombinant lipooxygenases and oxylipin metabolism for food quality [4]
Heat transfer in food, microwave operation, ultrasound assisted processing [4]
Kinetics of chemical reactions in foods [2]</td></tr>
</table>

	Dehydration of foods, Mass transfer in dehydration, Drying rate curve, Pychrometry [4] Physical separation processes in foods – filtration operation, membrane filtration [5] Food quality management, HACCP [3] Design of food processing plant [3]
Text Books, and/or reference material	Text Books Food Biotechnology by Kalidas Shetty Fundamentals of Food Biotechnology by Lee Fundamentals of Food Process Engineering, Romeo Toledo , Springer Fundamentals of Food Engineering, D G Rao, PHI References: 1. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals by Jean-Richard Neeser, J. Bruce German, CRC Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9036	**Biopharmaceutical Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	CO 1: To learn about the manufacturing processes of drug substance and drug products CO 2: To learn about the detailed design of a GMP compliant plant CO 3: To learn about downstream processing of biopharmaceutical products at commercial level CO 4: To learn about biopharmaceutical process start up CO 5: To learn about quality management in a biopharmaceutical industry						

Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6] Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [14] Role of process development group and manufacturing group in biopharmaceutical process start up. [2] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [4] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [4] Concepts of understanding controlling factors regulating cost of production of a biopharmaceutical product. [2]
Text Books, and/or reference material	Text Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH References Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9037</td><td>Biomaterials</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Biochemistry, cell biology, Chemistry</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Classify the biomaterials and recognize their production and properties. CO2: Explain the application areas of biomaterials
CO3: To realize the important basic properties and requirements for biomaterials
CO4: Recognize the importance of relationships between living tissues and biomaterials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Definition of biomaterials – biologically derived materials or materials compatible with biology. (2)
Common biomaterials: some proteins, many carbohydrates and some specializedpolymers. (4)
Collagen (protein in bone and connective tissues): Structure production and its use. (3)
Fibroin (protein in silk): Production and its use. (2)
Production of these proteins by conventional cloning methods. (3)
Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; (8)
Biopolymers: Synthesis from a simple biological monomer (eg., hyaluronate polymers); Dextrans (used in chromatography columns); Rubber Like materials produced by bacteria and fungi (Polyhydroxybutyrate PHB), Polycaprolactone(PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligeneseutrophus; Biodegradable polymers (8)
Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. (8)
Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems.(4)</td></tr>
</table>

Text Books, and/or reference material	Text Book: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Reference book: 1. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9038	**Biometallurgy**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Microbiology, Chemical Kinetics	CT+EA
Course Outcomes	**1:** To recapitulate the basics of bioenergetics and to understand the relevant biogeochemistry & microbiology. **2:** To learn about the concepts of bioleaching and biobeneficiation along with the microbiological aspects **3:** To learn about bioleaching processes with typical examples. **4:** To analyze the kinetics of bioleaching **5:** To understand the enzymatic mechanism of bioleaching.

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

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9039</td><td colspan="2">BioEnergy</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn about present energy scenario in the world and importance of alternate energy
CO2: Detailed study on biological solid fuels
CO3: Detailed study on biological liquid fuels to replace petrol and diesel
CO4: Detailed study on biological gaseous fuels
CO5: To learn about Indian scenario and approach to solve the problem</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4]
Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3]
Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4]
Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5]
Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6]
Liquid biofuels to replace petrol – methanol production.Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel.Butanol production and use. [6]
Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5]
The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6]
Jatropha cultivation, National hydrogen energy road map. [3]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Biofuels production, application and development. Alan Scragg, CABI.
2. Research articles</td></tr>
</table>

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9040	**Bioprocess & Plant Design**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Bioprocess Engineering, Bioseparation Technology	CT+EA

Course Outcomes	CO1: Learn about mass balance and energy balance in Bioprocess Engineering and Cell growth kinetics CO2: Learn about media sterilization and air sterilization including kinetics, design of batch and continuous media sterilizers and air sterilizer**s.** CO3: Study of bioreactors and their design aspects related to microbial, plant and animal cell culture products CO4: Study of Scale-up, Operation, Instrumentation and control of Bioreactors. CO5: Bioreactor design supporting systems; Pumps, Refrigeration, Boilers and Effluent treatment plants. CO6: plant design aspects

Topics Covered	**Introduction to Bioprocess Engineering and Systems: (10)** Mass balance and energy balance in Bioprocess Engineering, kinetics of microbial growth, batch, continuous and fed batch systems, components of bioreactors, material of construction, vessel size, Aseptic operations in bioreactors, Mass Transfer and Heat transfer Bioreactors. Mechanical fittings in bioreactors ,Project planning in Bioprocess Engineering **Sterilization of Bioreactors: (6)** Media sterilization, kinetics of media sterilization, Arrhenius equation. Design of batch and continuous sterilizers Air sterilization, kinetics of air sterilization, Design of Air Filters **Bioreactors and their Design: (8)** Batch, continuous stirred tank Bioreactors (CSTR), Plug flow Bioreactors (PFR). Enzyme immobilized bioreactors ,Fluidized bed bioreactors, Bubble column bioreactors, Air- lift bioreactors, Hollow- fibre bioreactors, Membrane bioreactors Bioreactors for plant and animal cell culture systems **Scale-up, Operation, Instrumentation and control of Bioreactors: (4)** Scale up criteria, Measurement systems and their control in Bioreactors, Feedback control, Computer control Bioreactors. **Bioreactor design supporting systems: (6)** Reciprocating and Centrifugal Pumps; Boilers for Steam generation-Water Tube and Fire Tube boilers; Refrigeration systems; Effluent treatment systems-Aerobic and Anaerobic. **Plant Design (8)** Plant Location and Site Selection, Site layout, Utilities, Environmental considerations, Equipment cleaning, Culture cell bank, cGMP aspects, Bioprocess validation, Safety Considerations, Process economics.
Text Books, and/or reference material	Text Books: 1. Shuler M.L, Kargi F, '*Bioprocess Engineering-Basic Concepts'*, Prentice Hall of India Ltd. 2. Aiba S, Humphrey A E and Millis N F, '*Biochemical Engineering'* , Academic Press 3. Stanbury P F and Whitaker A, *'Principles of Fermentation* Technology', Pergamon Press 4. Bailey J E and Ollis D F, Biochemical Engineering Fundamentals,' McGraw Hill Reference Books: 1. Doran P M, 'Bioprocess Engineering Principles', Academic Press 2. Sinnott, R.K, 'Coulson and Richardson's Chemical EngineeringVol.3& Vol.6,', Butterworth-Heinemann

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9041</td><td>Advanced rDNA & Cellular Biotechnology</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Cell Biology, Biochemistry, Immunology, Molecular Biology & rDNA Technology, Microbiology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 :Learn the concept about working of Host system , vectors.specfic enzymes
CO2 : Formulate the strategies for r proteins from specific cells,media selection and their modification.
CO3: By applying knowledge of cellular technologies, purification specific bioreactors can be setup for commercial level production of valuable compounds for mankind.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1 : Tools and general Methodology Recombinant DNA Technology: Vectors types and their importance. Selection of host and its characteristics, Cloning and screening strategies for gene and gene expression with specific examples. (6)
Module 2 : Manipulation in Gene Expression and Protein Production in Prokaryotes and Eukaryotes;Regulatable promoters role; Vector design for increasing protein, Fusion protein , protein stability ; overcome oxygen limitation ,DNA integration into host chromosome, Metabolic load, Increasing Secretion ;Yeast espression system Cultured insect cell expression systems;Microbial Cell factories for insulin production.Modified microorganisms for waste degradation, Synthesis of commercial from recombinant microorganisms Ascorbic acid , Indigo, amino acids antibiotics, Engineering human interferon , Human growth hormones, DNAse I and Aginate lyase. (10)
Module 3 : Animal cells as Bioreactor: Cultivation systems for cell and tissue culture: Animal cell cultures maintenance and modifications. Vector design for mammalian gene expression ; CHO cells and its modification to enhance its potential in production of</td></tr>
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	recombinant proteins; Animal cell culture fermenter. Cell immobilization techniques. Large Scale Production of r Protein, Types of Fermenter ,Two stage fermentation in Tandem air lift reactor for T4 DNA Ligase. Separation of products**.(10)** **Module 4**: **Plants as bioreactors** for bio Pharmaceuticals production:Plant tissue culture techniques Cell suspension cultures and bioreactor technology, secondary metabolites, plant biosynthesis of alkaloids, flavonoids, terepenes, phenols, regulation and commercial importance.Plant and plant cell culture derived r Therapeutics and its purification**.(10) Module 5** : **Recent advanced tools** for Forensic studies,Molecular Diagnostics, Gene therapy. Environment cleaning programme**.(6)**
Text Books, and/or reference material	**Text/ Reference Books :** 1. Principles of Gene Manipulation. Old and Primrose- Blackwell scientific Pub. 2. Recombinant DNA Technology. Watson JD et al., Scientific American Book Series 3. Molecular biotechnology Principles and applications of r DNA technology. Bernard R.Glick.Jack J Pasternak. ASM Press ; Washington DC 4. Culture of Animal Cells: A Manual of Basic Technique. R. Ian Freshney Wiley-Liss. 5.Principles of Gene Manipulation. Sandy B. et al., Blackwell Publishers

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9042	**Animal Biotechnology**	PEL	3	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Genetics and Molecular Biology		CT+EA					
Course Outcomes	1. Learn about animal cell culture technique in laboratory scale. 2. Learn about technique for animal in large scale. 3. Learn about various techniques in animal biotechnology. 4. Learn about transgenic and knock animal techniques and its application. 5. Learn about techniques and importance of gene therapy 6. Learn about IVF technique and its importance. 7. Learn about stem cells and its applications.						

Topics Covered	1. History scope and prospect of animal cell culture: History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions.Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization. 2. Growth and scale up: Cell growth characteristics and kinetics, Micro-carrier attached growth, Cell culture in continuous, perfusion and hollow fiber reactor, Mass transfer in mammalian cell culture. 3. Technology – Present and future: Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering. 4. Transgenic and Konck out Animals: Methodology, Embryonic Stem Cell method,
	Microinjection method, Retroviral vector method, Applications of transgenic animals 5. Gene Therapy: Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system,Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vectorsystem, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents. 6.In Vitro Fertilization and Embryo Transfer:Composition of IVF media, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA. 7.Stem cells: Classification and types, Sources, Markers, Differentiation signals, application, IPSC
Text/ References	1. Animal Cell Culture by John R.W. Masters; Oxford University Press 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

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<tr><td>BT9043</td><td>Immunotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Immunology, Cell biology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO 1. The students will gain insight into the immune response to various infectious and non-infectious and autoimmune diseases.
CO 2. In depth understanding of the impact of different receptors cell signaling pathways in immune response will allow their knowledge to apply for future application.
CO 3. The latest technologies used in disease detection and antibody production
CO 4. To apply the concept and strategies for immunotherapeutics production from cell lines at higher scale.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamental and cell signaling in immune system: Components of innate and acquired immunity; major histocompatibility complex and immune responsiveness, molecular basis of antibody diversity, self–non-self discrimination and immunological memory. Immunoglobulin superfamily; B and T cell activation B-cell receptor; T-cell receptor; cytokines, chemokines and their receptors; signal transduction pathways. (8)
Host-Pathogen interaction; Molecular basis of Immune diversity, Immunity and infection to bacteria, virus, protozoa, fungi. tumor. Cancer, Auto immune disease, Inflammation. Discussion with examples for each category.Research on progress for immunotherapy (8)
Principles and applications of laboratory tests in Immunology: Principles of antigen-antibody interactions;production and purification of polyclonal antibodies; antibody assays - precipitation, agglutination, immunoelectrophoresis advanced immunological techniques - RIA, ELISA, Western blotting, immunofluorescence, immunoelectron microscopy, flow cytometry and ELISPOT assay, surface plasmon resonance; total and differential counts in human peripheral cells, separation of monocytes from peripheral cells; lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, HLA typing (6)</td></tr>
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	Cellular technologies and animal cell bioreactors : Large scale production of interferon, therapeutic agents. Generation of monoclonal antibodies through Hybridoma technology,. Use of specific cells and cell lines for therapeutic purpose. Genetic engineering techniques to make human antibodies- chimeric antibodies & humanized antibodies, clinical use of monoclonal antibodies. **(8)** **Vaccinology:** Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines; mRNA based vaccine, Peptide vaccines; conjugate vaccines, Dendritic cell vaccine; **(4)** **Clinical Immunology**- Hypersensitivity; Types of autoimmune diseases and their treatment; Transplantation and immunosuppressive therapy; Tumor immunology – Tumor antigens; Therapeutic uses of cytokines. **(8)**
Text Books, and/or reference material	**Text Book**: Kuby Immunology By Owen, Punt, & Stranford, 7th, Seventh Edition, 2013, Macmillan press. 2. Abul K. Abbas, Andrew K. Lichtman & Jordan S. Pober (Eds.). Cellular and Molecular Immunology. 3rd Edn. W.B. Saunders Company, 2001 **Reference books:** 2. The Elements of Immunology by FahimHalim Khan, Pearson Education, 2009. 3. Essentials of Immunology: Ivan Riot- Blakswell Scientific Publications, Oxford, 6th Edition. 4. Infection and immunity by John Playfair and Gregory Bancroft, 3rd edition, Oxford Univ.press. 2008. 5. Monoclonal antibodies: Principles and practice by J.W. Goding. 3rd edition, Academic Press.

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9044	**Molecular Modeling & Drug Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Proteomics, Protein Engineering		CT+EA					

Course Outcomes	CO1: To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. CO2: To learn the fundamental concepts of structure-activity relationships CO3: To elucidate the mechanism of action of drugs (drug-receptor interaction) CO4: To learn rational design of novel, biologically active compounds.
Topics Covered	Introduction to molecular Simulation Techniques (5) Quantum chemistry for Modeling of small molecules (5) Molecular Dynamics Methods- Molecular Dynamics of rigid non linear polyatomic molecules in ensembles, Structural information from M.D. (5) Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable force fields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design: Principles of receptor based de novo ligand design. Rigid body molecular Docking. (7)
Text Books, and/or reference material	Text Books: A R Leach-Molecular Modelling,. Principles and application 2nd edition–Prentice Hall. Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London Reference Books: G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley Scolnick.J.(2001) Drug Discovery and Design Academic Press, London N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design.* Academic Press, San Diego, 1996.

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9045	**Regenerative Medicine & Translational Research**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Biochemistry, Genetics, Molecular Biology		CT+EA					
Course Outcomes	CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signaling molecules and the use of such factors for tissue production in-vitro. CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodeling to correct these changes CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy. CO4: To understand the recent advances on application the regenerative therapy from well characterized case studies.						

Topics Covered	An Introduction to Stem Cells(2) Adult Stem Cells (1) Embryonic Stem Cells (1) Induced Pluripotent Stem Cells (1) Hematopoietic Stem Cells (1) Mesenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) Molecular and Cellular Bases of Organ Development (6) Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals(4) Molecular Bases of degenerative disease (1) Therapeutic Uses of Stem Cells with examples (2) In vivo Regeneration of Tissues by Cell Transplantation (2) IPS Cells as Experimental Models of Neurodegenerative Disorders: use of them as disease modelling platform, novel drug testing and tissue regenerative therapy and implantation studies(2) Studies of Patients Treated with Stem Cells, The modalities of treatment, Preparation of cells/tissues/scaffolds and Transplantation procedure(3) Tissue Regeneration Driven by Growth Hormones (2) Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs(8) Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)
Text Books, and/or reference material	Text Books: Stem Cells, Tissue Engineering And Regenerative MedicineBy: David Warburton 1stEdition. Principles of Regenerative Medicine by AnthonyAtala Robert Lanza Tony Mikos Robert Nerem,3rd Edition. Translational Regenerative Medicine byAnthony Atala and Julie G. Allickson Reference Books: The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G.Tenth edition. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, IstEdtion

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9046	**Microbial Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Cell Biology and Genetics Biochemistry and Enzyme Technology, Microbiology and Fermentation Technology	CT+EA
Course Outcomes	CO1: To acquire knowledge on microbial based products of commercial importance at environmental ,industrial and clinical relevance. CO2:To Apply knowledge based skills in developing strategies to improve yield and reduce cost of the microbial process and or derived products CO3:To generate pilot plant design via understanding in microbial kinetic studies. and scale up approaches. CO4:Able to impart the knowledge in synthesis and separation of microbial products at highest level of purity as per the required demand.
Topics Covered	UNIT 1:An overview of traditional and modern applications of microbial products. Concept of Overproduction of metabolites. Strain improvement strategies for improved production of valuables via Classical (Random Mutagenesis)and advanced approches(Genetic engineering, Site directed mutagenesis, Protoplast fusion). Case studies on strategies for enhanced production of Insulin, Penicillin, and enzymes of microbial origin with emphasis onhost cell engineering ;vector design, optimization of media and process parameters. Concepts on cost analysis for better yield using improved technology (10) UNIT 2: Process technology for the production of microbial biomass. , primary metabolites and secondary metabolites. Growth and product kinetics .Fermentation, raw materials for fermentation, submerged, surface and solid-state systems, whole cell and enzyme immobilized systems.Technological processes for industrial manufacture of Yoghurt, acidophilus milk, Koumis, kefir, cheese, bread, alcoholic beverage, vinegar. Lactic acid and oriental fermented food of commercial importance. Equipment involved in the commercially important food processing methods.(10) UNIT 3: Different regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes, Induction, nutritional repression, carbon catabolite repression, Crabtree effect, feedback inhibition and feedback repression, with respect to biomass and valuables production.Case studies on Heterologous gene expression and secretion in Gram-positive bacteria with industrial applications. Biotechnology of protein secretion systems in Escherichia coli.(10)

	UNIT4:Environmental factors and stress in Bacterial community and their response.Microbial waste degradation (Heavy metal ,phenolics,and hydrocarbon); Microbes in bioenergy production (bioethanol , biobutanol,algal biofuel); Application based perspectives of Metagenomics. Plant microbe interaction microbe-mediated enhancement of nitrogen and phosphorus content for crop improvement; Genetic control of the cell cycle and microbial pathogenesis.(10) UNIT 5: Primary & secondary separation process for recovery of microbial products - Biomass removal . Biomass disruption , Membrane based techniques. Extraction -solvent, aqueous two phases, super critical, and Adsorption. Chromatography, Precipitation

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9047	**Environmental Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Microbiology, Molecular Biology, Biochemistry		CT+EA					
Course Outcomes	Learn about scope, applications (pollution prevention and abatement) and different parameters in the field of Environmental Biotechnology. Learn about different modes of microbial interaction with inorganic and organic pollutants. Learn about aerobic and anaerobic biotransformation mechanisms and about the scope of genetically engineered organisms in bioremediation. Learn about role and requirements of microorganisms, Microbial community composition and the interactions between community members for enhanced bioremediation. Learn about different strategies of bioremediation – in-situ bioremediation approaches, ex-situ bioremediation approaches, biostimulation, bioaugmentation, monitored natural attenuation, phytoremediation. Learn about different factors regulating bioremediation. Learn about waste water characteristics. Learn about effluent treatment processes. Learn about various suspended growth Aerobic effluent treatment processes. Learn about various attached growth Aerobic effluent treatment processes. Learn about Anaerobic digestion process. Learn about design of reactors for effluent treatment processes.						

Topics Covered	Unit 1-Introduction to Environmental Biotechnology: definition, scope of applications; Biotechnology for pollution prevention and pollution abatement (green technologies – bioleaching of metals, microbially enhanced oil recovery, biodegradable polymers, biobleaching, biodesulphurization, biofuel production, biogas, bioremediation, etc.) (3) Unit 2 -Types of pollutants, sources of pollutants, magnitude of contamination problem, merits and limitations of bioremediation, bioremediation of organic and inorganic pollutants. Microbial interactions with heavy metals/radionuclides – bioaccumulation, biosorption,
	biotransformation, bioprecipitation, applications of metal-microbe interactions, biomining, engineering microorganisms for metal bioremediation (3) Unit 3 - Biodegradation principles – microbial processes, biotransformation, mineralization, detoxification, activation, cometabolism and growth associated degradation. Requirements for biodegradation, cooperation between different microbial species for enhanced biodegradation, Implications of recalcitrance, acclimation, biotransformation mechanisms – genes, enzymes, reactions, Biodegradation pathways and metabolites, effect of contaminant structure on biodegradability. (8) Unit 4 -Bioremediation strategies – microbial community composition and interactions between community members for enhanced bioremediation, natural attenuation and accelerated bioremediation, aerobic, anaerobic, ex-situ bioremediation approaches, in-situ bioremediation approaches, biostimulation, bioaugmentation, Phytoremediation - phytoextraction, rhizofiltration, phytodegradation, phytovolatilization, rhizoremediation, phytostabilization. (8) Unit 5 -Waste Water & Sludge treatment:Characteristics and analysis of waste water, Treatment of waste water of sewage & Industry. Bio-kinetics coefficient and its application in waste water treatment. Basic design concepts and calculations for waste water treatment of:Preliminary treatment units – screening,grit removal , removal of oil and grease; Primary treatment units- settling tank, flotation.Biological treatment:Aerobic: Activated sludge process, secondary settling tank, trickling filter, waste stabilization pond.Anaerobic : Anaerobic reactors for treatment of waste water- Anaerobic Digesters, Upflow Anaerobic Sludge Blanket Reactor(UASB), Fluidized Bed Biofilm Reactor(FBBR), Treatment and disposal of sludge, Solid waste management , Advanced Waste Water Treatment- Limitations of conventional treatment, pathogen removal, toxic substances removal, phosphorous and nitrogen removal (12) Unit 6 -Industrial Waste:Approach to design, process design parameters - Characteristics, analysis and treatment of wastes from different Industry like: dairy industry, fermentation, slaughter house, tanning, dye, pulp and paper, distillery, petroleum, heavy metal pesticides, food and beverage, antibiotics etc. Treatment of biological industry wastes, Treatment & disposal of radioactive waste.(8)

Text/ References	i) ediation and Natural Attenuation: Process fundamentals and mathematical models by P J J Alvarez and W A Illman, Wiley-Interscience water treatement: Concepts & design approach, G L Karia, R A Christian, PHI supply & waste water engineering, B S N Raju, Tata Mc Graw Hill Publications ial wastes, Their disposal & Treatment; Willem Rudolfs, Reinhold Publishing Corporation, American series icrobiology; N S Subba Rao; Oxford & IBH Publishing Co. Pvt Ltd. water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill nmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. & Greogia; PHI & wastewater Technology; Hammer, Mark J, Mark J Hammer; PHI radation & Bioremediation (1999), Martin Alexander, Academic press. Bioremediation engineering; design and application 1995 John. T. cookson, Jr. Mc Graw Hill, Inc. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., Environmental Pollution Control Microbiology by Ross E Mc Kinney, Dekker publisher Environmental Engineer's Mathematics Handbook by Frank R Spellman & Nancy E Whiting. CRC Publication Biology of wastewater treatment by N F Gray; Imperial College Press.

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9048	**Protein structure, folding & misfolding**	PEL	3	0	0	3	3
Biochemistry, Cell Biology, Molecular Biology		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To learn about protein structures and its classification into structural groups. CO2: To understand protein-DNA interactions and the origin of selectivity and specificity in this process CO3: To learn how to determine protein structure CO4: Understanding of protein folding mechanism and how protein misfolding is related to several human diseases.						

Topics Covered	Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, fibrous proteins. (10) DNA structures. DNA recognition in prokaryotes by helix-turn-helix motifs. (6) DNA recognition by eukaryotic transcription factors, specific transcription factors. (6) Structural feature of common proteins involved in enzyme catalysis, signal transduction and immunity. (8) Protein Structure determination (4) Protein folding: thermodynamics, kinetics and chaperones. (4) Protein misfolding and Disease. (4)
Text Books, and/or reference material	Text Book: 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge Reference book: 1. Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9049	**Methods in Computational Biology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Bioinformatics, C programming		CT+EA					
Course Outcomes	CO1: Learning computational skills to examine biological information CO2: Learning and developing computational tools for analysis of large biological data CO3: To understand the models of biological systems constructed from experimental measurements CO4: Learn about machine learning and statistical tools to construct models from large existing datasets						

Topics Covered	Algorithms in Computing: Biological and Computer algorithm, Fibonacci problem, Dynamic Programming, Time and space complexity of algorithms (7) Programming languages- Algorithm, Flowchart, Compiling, Testing and Debugging (7) C programming – C language Introduction, Identifier , Variables, Constants, Operators, Input statement, Output statement, Conditional and Unconditional Control Statement, Looping Statement: while, do-while, for loop, Arrays. Read, write files (biological data) (10) Clustering and Trees: Hierarchical Clustering, k-Means Clustering, Evolutionary Trees, Distance-Based Tree Reconstruction, Reconstructing Trees from Additive Matrices, Character-Based Tree Reconstruction, Small and large Parsimony Problem. (10) Hidden Markov Models: Markov processes and Markov Models, Hidden Markov Models (8)
Text Books, and/or reference material	Text Books: Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins" by A D Baxevanis and B F F Ouellette Protein Bioinformatics: An Algorithmic Approach to Sequence and Structure Analysis by Ingvar Eidhammer, Inge Jonassen, William R. Taylor Reference Books: Introduction to Computational Biology by Bernhard Haubold Bioinformatics: Genes, Proteins and Computers by Christine Orengo, David Jones, Janet Thornto

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9050	**Nano-biotechnology & Nanomaterials**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of biology, Chemistry and Physics		CT+EA					
Course Outcomes	CO1: Acquire advanced idea about nanoscale phenomenon CO2: To learn about the different investigation tools for the nanobiotechnology CO3: To learn about synthesis of diverse classes of nanomaterials CO4: To get comprehensive understanding of applications of nanotechnology in biology						

Topics Covered	Nanotechnology; introduction to miniaturization. (4) Investigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. investigation tools: nanoimprint lithography (8) Nanomaterials: organic and inorganic nanoparticles. (6) Molecular self-assembly and bottom up synthesis of nanomaterials. (6) Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6) Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6) Nanotoxicology. (4) Future Concepts in Nanobiotechnology. (2)
Text Books, and/or reference material	Text Book: 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. References Books 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9051	**Plant Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Cell Biology, Genetics, Molecular Biology & rDNA Technology		CT+EA					

Course Outcomes	CO1: To understand the concepts and techniques of plant tissue culture. CO2: To understand the basic methods of mapping and cloning plant genes. CO3: To learn the methodologies of genetic transformation of plants. CO4: To generate the ability to create genetically modified plants by means of plant breeding and genetic engineering with improved quality traits.
Topics Covered	History of Plant Tissue Culture (1) Lab requirements and general techniques (1) Tissue Culture Media (1) Hormones in plant tissue culture (4) Cellular Totipotency (1) Somatic embryogenesis (1) Cell Suspension Culture (1) Haploid Production, (1) Somaclonal variation (1) Protoplast Isolation and Culture (1) Micropropagation in plants(1) Morphological Markers, Biochemical Markers, (1) molecular markers (DNA / protein) – RFLP, RAPD,AFLP, SSLPs, ESTs, SNPs etc., (6) Molecular mapping, Map-based cloning, (2) marker-assisted selection, marker-aided breeding, (1) Cloning of plant genes using activation tagging, transposon tagging etc. (2) Direct and indirect methods of genetic transformation of plants, (2) *Agrobacterium* mediated gene transfer, Ti Plasmid, (3) vectors for plant transformation, selectable and screenable markers, (1) gene constructs, strategies for genetic transformation of plants,(2) gene silencing, RNA interference, (1) genome editing in plants, (1) resistance to biotic stresses, tolerance to abiotic stresses, genetically modified crops (5)
Text Books, and/or reference material	**Text Books:** H.S.Chawla, Introduction to Plant Biotechnology, Oxford &IBH Publishing co.Pvt..Ltd Slater.A.,NigelW.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. Bhojwani and Razdan –PlantTissue Culture: Theory and Practice 1996 Elsevier **Reference Books:** Butterworth & Heineman, Invitro Cultivation of Plant Cells, Biotol Series. H.E Street(ed): Tissue culture and Plant science, Academic press, London, 1974 GamborgO.L.,.Phillips G.C, Plant Cell, Tissue and Organ Culture, Narosa Publishing House

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9052</td><td>Metabolic Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="4">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic concepts of chemical reaction kinetics & stoichiometry; matrices, Biochemistry, recombinant DNA Technology</td><td colspan="4">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To learn about the basic concepts of Metabolic Engineering
CO2:To learn about the models of cellular reactions and to understand the regulation of metabolic pathways
CO3: To understand the manipulation of metabolic pathways to enhance the yield and quality of the products
CO4: To learn and understand the models and the concepts required for the purpose of metabolic flux analysis
CO 5: To study the methods and application of metabolic flux analysis
CO 6: To analyze metabolic networks</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Importance of metabolic engineering [1]
Review of cellular metabolism, Regulation of metabolic pathways, Examples of pathway manipulations: metabolic engineering in practice – enhancement of product yield and productivity [10]
Extension of product spectrum and novel products (antibiotics, biopolymers, polyketides, vitamins etc), Improvement of cellular properties [7]
Metabolic modeling: Introduction to models for cellular reactions- stoichiometry, rates, and yield coefficients of cellular reactions, black box stoichiometries [7]
Material balance & data consistency: Black box model; elemental balances, degree of reduction balances, Heat balance [7]
Biochemical reaction networks: simple metabolic networks, flux analysis in metabolic networks; Metabolic control analysis [7]
Xenobiotic degradation [3].</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
Metabolic Engineering: Principles and Methodologies, Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, Academic Press
Bioreaction Engineering Principles, Jens Nielsen, John Villadsen, Gunnar Liden,
Reference Books:
Pathway Analysis and Optimization in Metabolic Engineering, Néstor V. Torres, Eberhard O. Voit, Cambridge University Press
An Introduction to Metabolic and Cellular Engineering, S. Cortassa, M. A. Aon , A. A. Iglesias, D. Lloyd, World Scientific Publishing Company</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9053</td><td>Nutraceuticals & Nutrigenomics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment
(EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To establish the correlation between nutraceuticals with cell signaling pathway. CO2: To target nutraceuticals from different sources.
CO3: To understand the interaction between gut microbiota with functional food components and nutraceuticals.
CO4: To formulate the concept of nutrient gene interaction.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals.
Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics and transcription factors.
Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds.
Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria

Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in
Nutrigenomics</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Books
Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput,
Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John
Shi , CRC Press
Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press</td></tr>
</table>

	References: Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Hasler, Blackwell Publishing Professional

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9054	**Molecular Plant Pathogen Interactions**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Molecular Biology & rDNA Technology		CT+EA					
Course Outcomes	CO1: Development of basic concept of plant diseases and contribution of environment toward plant disease development. CO2: Understanding the genetics of plant pathogen interactions. CO3: Learning about mechanisms of host defense & pathogenesis. CO4: Development of knowledge toward developing control measures against phytopathogens.						
Topics Covered	Introduction to molecular plant pathology, Plant diseases, (4) Plant disease development and environment, (3) Effects of pathogen on plant physiology, (2) Biochemistry of plant defense reactions, (3) Plant-pathogen interactions, (3) Genetic regulation of resistance in host plants, (4) Genetic regulation of virulence in pathogen, (4) Mechanisms of host defense, (3) Mechanisms of pathogenesis, (3) Hormone signaling pathways, (7) Biotechnological approach for plant protection; (3) Genetically modified plants to protect against pathogens. (3)						

Text Books, and/or reference material	**Text Books:** Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. **Reference Books:** Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.

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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9055	**Cell Biology of Human Diseases**	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
Cell Biology, Molecular Biology and Biochemistry			CT+EA				
Course Outcomes	CO1: To understand the concepts of structure, organization and molecular signaling of cells which govern its function. CO2: To understand cellular defects leading to human diseases and apply such understanding to explain any given phenotype at the cellular or organism level. CO3: To learn the application of experimental methods and designs to solve cell biology questions in human diseases.						

Topics Covered	Overview of cell organizations and functions. (3) Experimentations in cell biology: Microscopy, genetic screens, cell fractionations and biochemical assays. (6) Cytoskeleton and extracellular matrix. Hypertrophic and dilated cardiomyopathies, epidermolysis bullosa simplex (EBS), muscular dystrophy, neurodegeneration, progeria, hearing defects. (4) Cell polarity, cell junctions and changes in cell shape. Neural Tube Defects.(2) Cell transport, endocytosis, exocytosis, membrane channels. Cholera and cystic fibrosis. (3) Cell migration during development and chemotaxis. Developmental defects and cancer.(1) Cilia structure and function and specialized sensory cells. Ciliopathies.(1) Protein processing, trafficking and transport. Microbial immune evasion,lysosomal storage disease, and diabetes.(4) Neurons, astrocytes and oligodendrocytes. Demyelinating diseases.(1) Mitochondrial function and mitochondrial genome. Mitochondrial diseases.(2) Cell cycle, cell proliferation, apoptosis. Cancer.(4) Stem cells and cell differentiation. Cancer.Regenerative medicine. (3) Nuclear organization and gene expression.Cancer.(2) Paper presentations (in group).(4)
Text Books, and/or reference material	Text Books: Molecular Biology of the Cellby Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.6th Edition, 2014.Garland Science. Reference Books: Molecular Cell Biologyby Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, HiddePloegh, Paul Matsudaira. 8th edition, 2016. Publisher: WH Freeman. . Cell and Molecular Biology: Concepts and Experiments by Gerald Karp. 6th Edition, 2010. Wiley.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours: Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	Credit
BT9056	**Infectious Diseases & Infection Control**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Immunology		CT+EA					

Course Outcomes	CO1: To understand about the spread of infectious diseases, the social impact and means of infection control CO2: To learn about bacterial infections and ways to tackle different bacterial diseases CO3: To learn the viral infections, vaccine development and challenges CO4: To learn about the protozoan and fungal infections and methods to combat them
Topics Covered	Origin of Infection; Evolution of infectious diseases; Concept of Infection: Immunity, Immune surveillance, Virulence, Pathogenesis (4) Introduction to pathogenic and non-pathogenic bacteria; Common bacterial diseases in humans; Basic mechanism of Bacterial pathogenesis; Bacterial survival in host cells- Quorum sensing; Bacterial virulence factors: Microbial structures and Toxins; infection; Bacterial immune evasion: Molecular Mimicry; Strategies for antibacterial therapy: Antibiotics, Other antibacterial compounds, and Antibiotic resistance- MDR and XDR strains. Bacterial vaccines. Case study: *E. coli* infection and diarrhoea (9) History of viral infections; Different viral diseases; Viral pathogenesis; Viral life cycle; Virus genomes and structure; Host –virus interactions; Host Immune reaction against viruses; Viral evasion of host immune surveillance; Antiviral pathways; Mutations in viral genome; Viral diseases and antibody response; Vaccine against viral diseases; Antivirals compounds for viral infections; Challenges in vaccine production against certain virtues; Case study: Influenza (9) Introduction to Protozoan Diseases; Different protozoan diseases, General mode of action of protozoa; Pathogenesis of protozoan diseases; Host response to Protozoans; Molecular signalling against Protozoa; Hypersensitivity and autoimmunity associated with Protozoan infections; Antimalarial drug development ; Case study: Plasmodium (7) General fungal diseases; Mode of action of fungal diseases; Immune response against fungal infection; Case study: Candidiasis; Infection caused by Yeast; Mode of action of Yeast infection; Case study: Ring worm (4) ; Infection and life style-Concepts of Microbiome; Neglected diseases (2) Spread of Infectious diseases; Disease epidemiology, Steps involved in epidemiology and epidemiological case studies; (3) Purpose of infection control, Regulations, policy and practice; Roles and responsibilities in infection control; Risk assessments; Principles of infection control procedures (4).
Text Books, and/or reference material	Text Books: 1. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases- 8thEdition; Volume I and II. By John E. Bennett , Raphael Dolin, Martin J. Blaser. SaudersPublication. 2. Immunology of Infectious Diseases. Edited By Stephan Kaufmann, Alan Sher, and Rafi Ahmed. American Society for Microbiology.

	Reference Books: 1. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. American Society for Microbiology 2. Practical Healthcare Epidemiology, 4th Edition. By Ebbing Lautenbach. Cambridge University press. 3. Principles and practice of clinical bacteriology-2nd Edition. By Stephen Gillespie, Peter M. Hawkey. John Wiley &Sons.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9057	**Project Engineering in Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	CO1: Learning about process flow diagram and basic concepts of plant design CO2: Learning about cleaning of process equipment and design of pipes and valves CO3: Learning about facility design and project planning CO4Learning about Planning, construction and commissioning of a biopharmaceutical manufacturing plant CO5: Learning about process economics CO6: Learning about production concepts						

Topics Covered	Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments & their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods (6) Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and clean ability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. (5) Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) (4) Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. (4) Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. (6) Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. (6) Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. (5) Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of
	manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. (6)
Text Books, and/or reference material	Text Books: Bioprocess engineering: system, equipment and facilities, B K Lydersen, N AD'Elia, K M Nelson. Wiley Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley Reference Books: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9058</td><td>Biological Computation</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Cell Biology, Biochemistry, Programming and Data Structure</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learning about different biological databases and the biological data stored in them CO2: To learn UNIX operating system to run bioinformatics resources
CO3: To acquire knowledge of Bash scripting and programming skills for analyzing biological data
CO4: To learn how to store and visualize biological data using computational methods</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Biological data and different file formats: Introduction to biological databases, sources of biological data, genbank, fasta file formats, interchanging of file formats (3) Introduction to Linux operating system: What is Linux OS, Kernel system, benefits of Linux for computational biology (3)
Bash programming for bioinformatics: Shell scripting, working in terminal with different commands, use of important commands such as sed, grep, awk (8)
C programming for bioinformatics: introduction to C, Identifier , Variables, Constants, Operators, Input statement, Output statement, Conditional and Unconditional Control Statement, Looping Statement: while, do-while, for loop, Arrays. Read, write files (biological data) (10)
Python scripting for bioinformatics: File handling in python, numpy, pandas etc (8)
Database management: Designing databases using SQL (5)
HTML and web-designing: Designing web-pages using HTML and java scripts (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
Computational Biology —Unix/Linux, Data Processing and Programming by Röbbe Wünschiers
Learning Python, 5th Edition by Mark Lu</td></tr>
<tr><td></td><td colspan="7">Reference Books:
Introduction to Bioinformatics by Arthur M Lesk
Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9059</td><td>Quality by Design for Biopharmaceuticals</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Bioprocess Engineering, Bioseparation Technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learning about the concept of QbD and importance in Biotechnology CO2: Learning about QbD for Biopharma production process
CO3: Learning about QbD for Biopharma purification process
CO4: Learning about QbD in biologics formulation and product development CO5: Learning about PAT tools
CO6: Learning about integration of PAT with QbD</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. QbD: Basic Concepts (2)
2. Considerations for Biotech Product QbD (3)
3. Risk Assessment to determine criticality of product quality attributes (3)
4. Case study on definition of process design space for a microbial fermentation step (4)
5. Application of QbD for Tangential Flow Filtrationprocess (4)
6. Applications of design space for biopharmaceutical purification processes (4)
7. Viral Clearance: A Strategy for QbD and the design Space (4)
8. Application of Quality by Design and risk assessment principles for the development of formulation design space (4)
9. Application of QbD principles to biologics product: formulation and process development (4)
10. QbD for Raw Materials (2)
11. PAT Tools for Biologics (4)
12. Evolution and Integration of QbD and PAT (4)</td></tr>
<tr><td>Text Books, and/or

reference material</td><td colspan="7">Text Books:
Anurag S Rathore, 2009, Quality by Design for Biopharmaceuticals: Principles and Case
Studies, Wiley.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9060</td><td>Medical Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Immunology, Molecular Biology, rDNA technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence.
CO2: Able to analyze the key features therapeutics and drugs in current scenario.
CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals.
CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Biochemical diagnostics in Medical Biotechnology 10
Clinical diagnosis of diseases: Inborn errors of metabolism and genetic disorders. Preimplantation diagnosis, pre-natal diagnosis-chorionic villus sampling, Amniocentesis. Molecular techniques for analysis of diseases: DNA polymorphism; ‘disease’ gene vs. ‘susceptibility’ gene; SNP detection: hybridization based assays; Polymerization based assays; Ligation based assays; Polymorphism detection without sequence information: Single nucleotide polymorphism and disease association; High throughput DNA sequencing and diagnosis; and Array based techniques in diagnosis.
Module 2: Drug Discovery and targeting: 10
Overview of inherited and acquired diseases for gene therapy; Identification of disease biomarkers and selection of drug targets; Proteomics and High throughput DNA screening for drug discovery; Gene silencing technology: therapeutic applications in treatment of influenza and HIV/AIDS; Tissue and organ transplantation; Transgenics and their uses. Delivery system development: Intracellular barriers to gene delivery; virus, Liposome and nanoparticles mediated gene delivery.
Module 3: Production of pharmaceuticals: 12
Production of pharmaceuticals by genetically engineered cells. Microbial transformation for production of important pharmaceuticals. Techniques for development of new generation antibiotics; Pharmacogenomics and pharmacogenetics of pharmaceuticals; Cellular and genotoxicity of pharmaceuticals.</td></tr>
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	Module 4:Clinical research: 10 Introduction and importance of clinical research, Drug development and phases of clinical trials: Designing clinical trials, Protocol designing, Ethical, safety and regulatory issues in clinical research, Drug regulatory concepts and accrediting agencies of the world (USFDA, TGA, ICH, WHO, ISO etc.), ICH-GCP Guidelines, Informed consent process, Role of CRC and CRA in clinical trials, Standard operating procedures, Guidelines to undertake clinical trials in India.
Text Books, and/or reference material	**Books** Lewis, Human Genetics, 7th Edition, WCB & McGraw, 2007. Maroni, Molecular and Genetic Analysis of Human Traits, 1st Edition, Wiley-Blackwell, 2001. Alberts et al, Molecular Biology of The Cell, 2nd Edition , Garland 2007 Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford Reference: Pharmaceutical Biotechnology ; Sambhamurthy & Kar , New Age Publishers Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

Department of Biotechnology							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9061	**Biological Chemistry**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of biology, chemistry and physics		CT+EA					

Course Outcomes	CO1: Understanding of the basic thermodynamic and kinetic aspect of biology. CO2: Getting familiarity with common principle of chemistry and chemical bonds CO3: To have a deeper understanding of energy flow in biology. CO4:To learn about the chemical reactions relevant to biological processes.
Topics Covered	Chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant). (8) Chemical and Biological Synthesis- Introduction to synthesis in biology. Chemical synthesis of peptides and proteins. Chemical synthesis of nucleic acids. Chemical synthesis of oligosaccharides. Chemical synthesis of lipids. Biological synthesis of biological macromolecules. Directed biological synthesis of proteins. Biological synthesis of nucleic acids, oligosaccharides and lipids. (6)
	Advance chemical and physical tools for Biology-Electronic and vibrational spectroscopy in biology, Circular dichroism spectroscopy, Vibrational spectroscopy, Fluorescence spectroscopy, X-ray crystallography, Mass spectrometry for proteomics. (8) Chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation- reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes. (8) Bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot). Types of organic reactions in biology; addition reactions- electrophilic, nucleophilic and free radical. Substitution reactions – electrophilic, nucleophilic and free radical. Elimination and Rearrangement reactions; Chemical insight of enzyme catalyzed reactions – proteases, polymerases, ribosomes. (12)
Text Books, and/or reference material	Text Book: 1. Ebbing, D. D., &Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin. 2. Averill, B., &Eldredge, P. (2007). Chemistry: Principles, Patterns, and Applications. San Francisco: Benjamin Cummings. 3. Cantor, C. R., &Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9062</td><td>Bioentrepreneurship</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic understanding of Biosafety guidelines</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1. To educate about various societal, governance and regulatory issues in biotechnology.
CO 2. To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey.
CO 3. To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products.
CO 4. To raise awareness about the ethical implications and safety rules in biopharma and GMO production management.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Bioentrepreneurship: Fundamentals of Marketing of biotechnological products, patent rules regarding product licensing. (4)</td></tr>
<tr><td></td><td colspan="7">Entrepreneurship traits & motivation: Growth of entrepreneurship, The marketing and selling of Biotechnology, Creating and marketing the image of the biotechnology company, Effective advertising and marketing.(8) Entrepreneurial development: Training, institution in aid of entrepreneur, Power and importance of Positioning of a company name and product. (6) Capacity building: Regulatory systems for health products in India: Regulatory authority India central (federal) and state (provincial) authorities. Central Licensing Authority. International collaboration of India with South East Asia Regulatory Network (SEARN). Quality management system (QMS). Regulatory functions : Control of clinical trials. Marketing Authorization, Registration Certificate for Import, Manufacturing Licence, Non-Objection Certification (NOC). Licence to manufacture Pre-approval batches, Import Licence, Export NOC for Biological Samples Pharmacovigilance for medicines, vaccines and blood products. (3)
Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, Workable marketing and the strength of distribution. Opportunities in international marketing. (8)</td></tr>
</table>

	Risk & benefit assessment: Steps involved in product licensing and technology transfer for commercialization of a biotechnological product. (6) **Ethical issues and Biosafety guidelines:** Food safety and environmental safety evaluation of genetically modified microbes, crops, animals (GMO & LMOs); Roles of Institutional Biosafety Committee, WHO, DBT guideline for institutional biosafety . Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms. Ethical implications of biotechnological products and techniques over human health. (7)
Text Books, and/or reference material	Text Book: 1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay Publications. 2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication. 3. Entrepreneurship development in India; Samiuddin, Mittal Publication References: • Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market • Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006. • Design and Marketing of New Products by Urban and Hauser,ISBN 0-13-201567-6 • Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences The national academy press