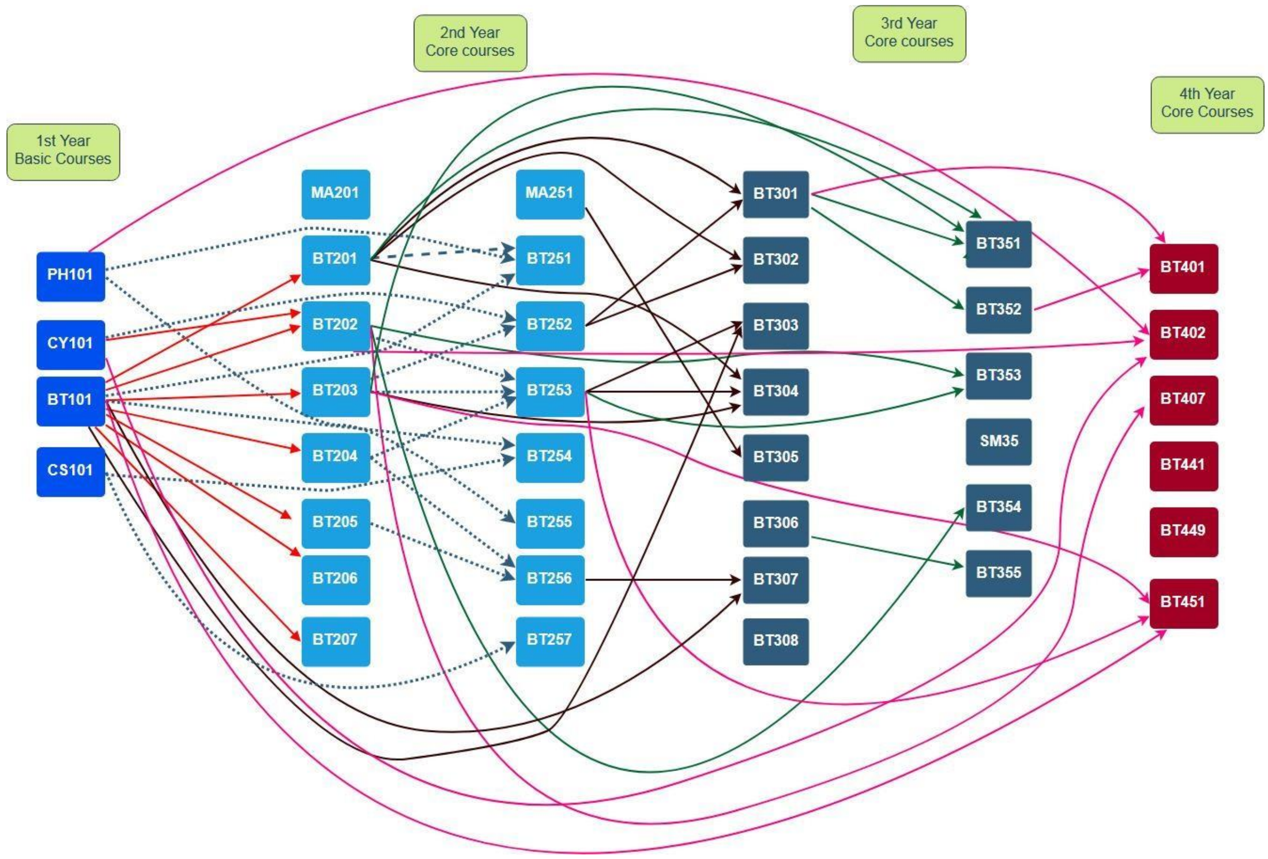
NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

SYLLABI
FOR B.TECH. PROGRAM

From 2017-18 Batch onwards

DEPARTMENT OF BIOTECHNOLOGY

PRE-REQUISITE CHART



CURRICULAR COMPONENTS
Degree Requirements for B. Tech in Biotechnology

No.	Particular	Accepted credits	Contact Hours / Week	Credits
1	Basic Science Core (BSC)	≥ 19		22
2	Engineering Science Core (ESC)	≥ 27		27
3	Humanities and Social Science Core (HSC)	≥ 06		06
4	Program Core Courses (PCC)	≥ 75		91
5	Departmental Elective Courses (DEC)	≥ 15		21
6	Open Elective Courses (OPC)	06		06
7	Program Major Project(PRC)	06		06
8	EAA: Games and Sports (MDC)	00		00
	Total			179
9	Semester	No. of credits		
	I Year – I & II Sem	23+23		23+23=46
	II Year – I & II Sem	24±2	26±2	22+22=44
	III Year – I & II Sem	22±2	26±2	24+24=48
	IV Year – I sem	22±2	26±3	22
	IV Year – II sem	18±3	23±3	19
				179

SCHEME OF INSTRUCTION
B. Tech. (Biotechnology) Course Structure

B. Tech. I - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA1	Mathematics – I	3	0	0	3	BSC
2	HS1	English for Technical Communication	2	0	2	3	HSC
3	PH1	Physics	3	1	2	5	BSC
4	EC1	Basic Electronics Engineering	3	0	0	3	ESC
5	CE1	Environmental Science & Engineering	2	0	0	2	ESC
6	BT1	Engineering Biology	2	0	0	2	ESC
7	CS1	Prob. Solving & Computer Programming	3	1	2	5	ESC
		TOTAL	**18**	**2**	**6**	**23**	

B. Tech. I - Year II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA1	Mathematics – II	3	0	0	3	BSC
2	ME1	Workshop practice	0	1	2	2	ESC
3	CY1	Chemistry	3	1	2	5	BSC
4	EE1	Basic Electrical Engineering	3	0	0	3	ESC
5	ME1	Basic Mechanical Engineering	3	0	0	3	ESC
6	CE1	Engineering Mechanics	3	0	0	3	ESC
7	ME1	Engineering Graphics	2	0	4	4	ESC
		Total	**17**	**2**	**8**	**23**	

B. Tech. II - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA201	Mathematics – III	3	0	0	3	BSC
2	BT201	Biochemical Thermodynamics	3	0	0	3	PCC
3	BT202	Biochemistry	3	1	0	4	PCC
4	BT203	Microbiology	3	0	0	3	PCC
5	BT204	Cell Biology	3	0	0	3	PCC
6	BT205	Biochemistry Lab.	0	0	3	2	PCC
7	BT206	Microbiology Lab.	0	0	3	2	PCC
8	BT207	Cell Biology Lab.	0	0	3	2	PCC
		Total	**15**	**1**	**9**	**22**	

B. Tech. II - Year II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA251	Mathematics – IV	3	0	0	3	BSC
2	BT251	Transport Phenomena in Bioprocess Systems	3	1	0	4	PCC
3	BT252	Bioprocess Calculations	3	0	0	3	PCC
4	BT253	Molecular Biology & Genetics	3	0	0	3	PCC
5	BT254	Biocomputing	3	0	0	3	PCC
6	BT255	Transport Phenomena in Bioprocess Sys. Lab.	0	0	3	2	PCC
7	BT256	Molecular Biology Lab.	0	0	3	2	PCC
8	BT257	Biocomputing Lab.	0	0	3	2	PCC
		Total	**15**	**1**	**9**	**22**	

III - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT301	Bioprocess Engineering	3	1	0	4	PCC
2	BT302	Biological Reaction Engineering	3	1	0	4	PCC
3	BT303	Immunology	3	0	0	3	PCC
4	BT304	Genetic Engineering	3	1	0	4	PCC
5	BT305	Biostatistics	3	0	0	3	PCC
6	BT306	Bioprocess Engineering Lab.	0	0	3	2	PCC
7	BT307	Immunology Lab	0	0	3	2	PCC
8	BT308	Genetic Engineering Lab.	0	0	3	2	PCC
9	EP349	EPICS	0	0	0	2*	
		Total	**15**	**3**	**9**	**24**	

*Credits are not considered for computation of SGPA and CGPA

III - Year II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT351	Bio separation Technology	3	0	0	3	PCC
2	BT352	Bioprocess Instrumentation & Control	3	0	0	3	PCC
3	BT353	Bioinformatics &Computational Biology	3	1	2	5	PCC
4	SM35	Engineering Economics & Accountancy	3	0	0	3	HSC
		Elective - I	3	0	0	3	DEC
5		Open Elective-I	3	0	0	3	OPC
6	BT354	Bio separation Technology Lab.	0	0	3	2	PCC
7	BT355	Bioprocess Instrumentation & Control Lab.	0	0	3	2	PCC
8	EP399	EPICS	0	0	0	2*	
		Total	**15**	**2**	**8**	**24**	

*Credits are not considered for computation of SGPA and CGPA

IV - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat.Code
1	BT401	Modeling, Simulation & Optimization of Bioprocesses	3	1	2	5	PCC
2	BT402	Instrumentation & Analytical Methods in Biotechnology	3	0	0	3	PCC
3		Elective – II	3	0	0	3	DEC
4		Elective –III	3	0	0	3	DEC
5		Open-Elective – II	3	0	0	3	OPC
6	BT407	Instrumentation & Analytical Methods in Biotechnology Lab.	0	0	3	2	PCC
7	BT441	Seminar	3	0	0	1	PCC
8	BT449	Project Work – Part A	0	0	3	2	PRC
		Total	**18**	**1**	**8**	**22**	

IV - Year II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT451	Biosafety Bioethics & IPR	3	0	0	3	PCC
2		Elective –IV	3	0	0	3	DEC
3		Elective-V	3	0	0	3	DEC
4		Elective-VI	3	0	0	3	DEC
5		Elective- VII	3	0	0	3	DEC
6	BT499	Project Work – Part B	0	0	6	4	PRC
		Total	**15**	**0**	**6**	**19**	

List of Electives

Elective I

BT361 Plant Biotechnology

BT362 Biomass & Biofuels Technology

BT363 Environmental Biotechnology

Elective II

BT411 Animal Biotechnology

BT412 Medical Biotechnology

BT413 Biopharmaceutical Technology

Elective III

BT421 Nano Biotechnology

BT423 Biomaterials Technology

BT423 Stem cell & Tissue Engineering

Elective IV

BT461 Protein Engineering

BT462 Metabolic Regulation & Engineering

BT463 Systems Biology

Elective V

BT471 Food Biotechnology

BT472 Machine Learning Techniques

BT473 Enzyme Technology

Elective VI

BT481 Neuro Biology

BT482 Omics Technologies

BT483 Oncology

Elective VII

BT491 Entrepreneurship in Biotechnology

BT492 Drug Design & Development

BT493 Biophysics

Open Elective I & II

BT390 Green Technology
BT440 Biosensors

Points to be noted:

1. Definition of Pre-requisite: The student should have studied that subject which is mentioned as Pre-requisite.
2. Course with same name but with different code number indicates that the subject pertains to different departments and also the syllabus is different.
3. EPICS (Engineering Project in Community Service) Project is offered in two parts as Part-A in III Year I Semester and Part-B in III Year II semester, with Two credits each. The credits earned are not counted for Computation of SGPA and CGPA. The course is not mandatory. It is Optional. Interested students can take it.
4. In first year syllabus, Engineering Biology is included in Physics cycle and Basic Mechanical Engineering is included in Chemistry cycle. This is with effect from 2018-2019 onwards.

MA 201	**MATHEMATICS - III** **(Common to EEE, MME, Chemical and Bio-Tech)**	**BSC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Mathematics - II (MA 151)

Course Outcomes: At the end of the course, student will be able to:

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function and Z- transform of a sequence
CO3	Determine the solution of a PDE by variable separable method
CO4	Understand and use of complex variables and evaluation of real integrals

Mapping of course outcomes with program outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4				`								

Fourier series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions(6)Fourier Transforms: Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations (6) Z-transforms: Z- transform and Inverse Z-transforms – Properties – convolution theorem- simple illustrations(6)Partial Differential Equations: Method of separation of variables - Solution of one dimensional wave equation, one dimensional heat conduction equation and two dimensional steady state heat conduction equation with illustrations (8)Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities - Residues - residue theorem, use of residue theorem to evaluate the real integrals of the type $\int_{0}^{2\pi} f(Cos\theta, Sin\theta)\,d\theta$, $\int_{-\infty}^{\infty} f(x)dx$ without poles on the real axis.(16)

Reading:

1. R.K.Jain and S.R.K.Iyengar, *Advanced Engineering Mathematics,* Narosa Pub. House, 5thedition, 2016.
2. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, *Higher Engineering Mathematics*, Khanna Publications, 44thedition, 2017.

BT201	BIOCHEMICAL THERMODYNAMICS	PCC	3 – 0 – 0	3 Credits

Prerequisites: PH101 Physics and CY101 Chemistry
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the laws of thermodynamics
CO2	Apply power and refrigeration cycles for bioprocesses
CO3	Understand the degrees of freedom, phase and chemical reaction equilibria
CO4	Calculate thermodynamic parameters involved in biochemical reactions
CO5	Differentiate between ideal and non-ideal solutions

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO2	2	-	3	-	-	-	-	-	-	-	-	-	-	-	1
CO3	3	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO4	3	2	1	2	-	-	-	-	-	-	-	-	2	-	-
CO5	3	1	3	-	-	-	-	-	-	-	-	-	1	-	-

Detailed Syllabus:

Concepts in Engineering Thermodynamics: First Law of Thermodynamics and Other Basic Concepts, Calculation of Work, energy and property changes in reversible processes, Second Law of Thermodynamics, Thermodynamics of Flow Process, Thermodynamic Properties of Fluids, Volumetric Properties of Real Gases, Maxwell's relationships and their applications Residual Properties Estimation of Thermodynamic Properties using Equation of State , Power cycles and refrigeration cycles.
Solution Thermodynamics: Partial Properties, Concepts of Chemical Potential and Fugacity, Ideal and Non Ideal Solutions, Gibbs – Duhem Equation, Excess Properties of mixture; Activity Coefficients, Activity Coefficient Correlations.
Phase and Chemical Reaction Equilibria: Criteria for phase equilibrium ,Vapor – Liquid equilibrium calculations for binary mixtures, Liquid – Liquid Equilibria and Solid- Liquid Equilibria, Introduction to Chemical Reaction Equilibrium, Equilibrium criteria for homogeneous chemical reactions; Evaluation of equilibrium constant and effect of pressure and temperature on equilibrium constant; Calculation of equilibrium conversions and yields for single and multiple chemical reactions.
Biochemical Thermodynamics: Energetics of Metabolic Pathways; Energy Coupling (ATP & NADH) Stoichiometry and energetic analysis of Cell Growth and Product Formation – - elemental Balances, Degree of reduction concepts; available -electron balances; yield coefficients; Thermodynamics of microbial growth.; Oxygen consumption and heat evolution in aerobic cultures; thermodynamic efficiency of growth, Energy balance equation for free cell culture ; Reaction thermodynamics. pH dependence of a Biochemical Reaction, Unfolding of a protein as a function of Temperature.

Reading:

1. J.M. Smith, H.C. van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw Hill, 2005
2. Stanley I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics, 4^{th} Edition, Wiley, 2006.
3. J.A Roels, Kinetics and Energetics in Biotechnology, Elsevier, 2003
4. Robert A. Alberty, Biochemical Thermodynamics: Applications of Mathematica 1^{st} Edition, Wiley-Interscience, 2007.

BT202	BIOCHEMISTRY	PCC	3 – 1 – 0	4 Credits

Prerequisites: PH101 Physics, CY101 Chemistry& BT101 Engineering Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Classify bio-molecules
CO2	Understand complex biochemical pathways within living cells
CO3	Understand the physiological functioning of the cells
CO4	Understand catabolic and anabolic metabolism
CO5	Determine the kinetic parameters of enzymatic reactions

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	2	2	1	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	1	-	2	1	-	-	2	-	-
CO3	-	-	-	-	-	-	-	1	-	-	2	-	-	1	-
CO4	3	2	2	-	3	-	2	-	-	-	-	1	-	-	1
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Detailed Syllabus:

Introduction to Biochemistry: Chemical foundations of Biology - pH, acids, bases, buffers, weak bonds and covalent bonds. Amino acids and Peptides: Classification of amino acids, Structure and properties of amino acids, Peptide bond and peptide Proteins: Structure and Classification of Proteins. Primary structure, Secondary structure, Tertiary structure and Quaternary structure, aggregated proteins, Structural importance in function, Denaturation and Renaturation. Nucleic acids: Structure of nucleic acids, Structure of DNA, specialized secondary structures, Principle kinds of RNA and their structures, Carbohydrates: Structure and functions of carbohydrates and glycoproteins. Lipids: Structure of Fats and Oils, Phospholipids, membrane lipids, Vitamins: Introduction, classification and functions of vitamins, disease of vitamins deficiency.
Metabolism: Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway, The Citric Acid Cycle, Amino Acid Oxidation, Oxidative Phosphorylation and Photophosphorylation, DNA Metabolism, RNA Metabolism, Protein Metabolism, Analytical techniques in biochemistry for small molecules and macro- molecules for quantification.
Enzymes and Enzyme Kinetics: Enzymes as biological catalysts, classification, Examples of enzymes catalyzed reactions, Michaelis–Menten approach to enzyme kinetics, and mechanism of enzyme action

Reading:

1. David L. Nelson and Michael M. Cox, Lehninger Principles of Biochemistry, 7th Edition, W. H. Freeman, 2017
2. Victor Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly and P. Anthony Weil, Harpers Illustrated Biochemistry, 30th Edition, Tata McGraw – Hill, 2015
3. Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Jr., and Lubert Stryer, Biochemistry, 8th Edition, Macmillan, 2015
4. Shawn O. Farrell and Mary K. Campbell, Biochemistry, 8th Edition, Brooks/Cole, 2013

BT203	MICROBIOLOGY	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT101- Engineering Biology.
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the diversity of microorganisms
CO2	Understand the interaction of microorganisms with their environment
CO3	Understand the role of microorganisms in environmental remediation
CO4	Select appropriate methods for control of the growth of microorganisms
CO5	Understand the principles of bacterial genetics

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	-	2	2	2	-	-	-	-	-	-	3	1	2
CO2	3	-	-	2	-	3	-	1	-	2	-	-	3	-	3
CO3	3	2	-	2	-	2	-	3	-	3	-	-	3	2	3
CO4	-	-	-	-	3	3	2	1	-	-	-	-	3	3	2
CO5	3	2	-	2	2	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:
Spontaneous generation versus Biogenesis of microorganisms - germ theory of disease –Koch's Postulates, Classical Characteristics of Microorganisms: Morphological, chemical, cultural, metabolic, antigenic, genetic, pathogenicity and ecological characteristics –Molecular characteristics. Bacterial cell structure: Bacteria: Size, shape and arrangement - structures external to the cell wall - the cell wall - structures internal to the cell wall - spores and cysts, Cultivation of Bacteria: Nutritional requirements - physical conditions required for growth - Choice of media and conditions of Incubation – reproduction and growth – quantitative measurement of growth – Selective methods – methods of isolation, maintenance and preservation of pure cultures. Control of Microorganisms: Fundamentals of control - physical agents - chemical agents – antibiotics.
Fungi, Algae and Protozoa: Yeasts and Molds – characteristics, morphology, reproduction and physiology of fungi - Occurrence, characteristics of Algae - biological and economic importance – lichens – morphology, reproduction and physiology of Protozoa. Viruses: Viruses of Bacteria – Bacteriophages - Discovery and significance – general characteristics, morphology and structure - classification and nomenclature - bacteriophages of *Escherichia coli* - Structure, composition and classification of viruses of animals and plants.
Bacterial Genetics: Study of microbial genetics - inheritance of characteristics and variability - phenotypic changes and genotypic changes - bacterial recombination - bacterial conjugation, transduction, and transformation.
Introduction to Applied Microbiology: Microbial Interactions -Microbiology of soil - biogeochemical roles of microorganisms – Aquatic Microbiology - Wastewater treatment procedures.
Reading:

1. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton: Prescott, Harley, and Klein's Microbiology, McGraw Hill Higher Education, International Edition, 10th Edition, 2016.
2. Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley and David A. Stahl: Brock Biology of Microorganisms, Pearson, 15th Edition, 2017
3. John L. Ingraham, Catherine A. Ingraham: Introduction to Microbiology, A case History Approach, Thomson Brooks/Cole, 3rd Edition, 2004

BT204	CELL BIOLOGY	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT101- Engineering Biology.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the cell theory and cellular compartmentalization
CO2	Understand the structure and function of the plasma membrane and cell organelles.
CO3	Understand the molecular mechanisms of cell cycle.
CO4	Relate the importance of cell cycle on cancer development
CO5	Understand the role of apoptotic cell death in cellular development
CO6	Study the signal transduction process in a cellular system

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-		1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO3	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO4	3	2	-	1	-	-	-	-	-	-	-	-	3	1	2
CO5	2	-	-	1	-	-	-	-	-	-	-	-	3	-	-
CO6	2	-	-	1	-	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:

Cell structure and function: Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Intracellular Compartments: Structure and functions of Nucleus, Endoplasmic Reticulum, Golgi complex, Mitochondria, Lysosomes, Peroxisomes, Plastids etc.

Cell Membranes: Introduces membrane components, phospholipid bilayers, Membrane proteins and their interaction in real membranes, Basics of membrane transport systems (both active and passive).Cell division: Molecular Mechanics of Mitosis & Meiosis, Checkpoint cell cycle control, Activation and control of cyclin dependent kinase activity.

Cell signaling: Intracellular signaling and types of signal receptors, Chemoreceptors of Bacteria (Attractants & Repellents), Signal Transduction by hormones - Steroid / Peptide hormones, Concept of Secondary messengers, cAMP, cGMP, Protein Kinases, G Proteins, Receptors & Non - receptors associated tyrosine kinases.

Embryonic and adult stem cells, Cell differentiation, Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer – Proto oncogene, Tumor Suppressor gene.

Reading:

1. Bruce Alberts, Alexander D. Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts: Molecular Biology of the Cell, 6th Edition, Garland Science, 2015
2. Geoffrey M. Cooper and Robert E Hausman, The Cell: A Molecular Approach, 7th Edition, Oxford University press, 2015

BT205	BIOCHEMISTRY LABORATORY	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT101- Engineering Biology.
Course Outcomes: At the end of the course the student will be able to:

CO1	Estimate the concentration of biological macromolecules
CO2	Identify and characterize biological macromolecules
CO3	Separate biomolecules using Chromatography and Electrophoresis
CO4	Conduct biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents.

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	-	2	-	-	1	3	-	-	-	-	-	-	-
CO2	-	-	1	-	-	1	-	-	1	1	-	-	2	-	-
CO3	-	3	-	-	3	-	-	3	-	-	2	-	-	1	-
CO4	2	-	-	-	-	2	2	-	2	-	-	1	-	-	1

Detailed Syllabus:

Laboratory safety &Hygiene, Units and measurements, Basic statistical concepts for biochemical analysis, Qualitative analysis of Carbohydrates, amino acids & proteins, Quantitative estimation of protein by Biuret method& Lowry method, Quantitative estimation of reducing sugars by DNS method, Quantitative estimation of total sugars by Anthrone method, Quantitative estimation of DNA by Diphenylamine method, Quantitative estimation of RNA by Orcinol method, Determination of Absorption Maxima (λ_{max}),Estimation of Nucleic acids & Protein purity by spectrometric analysis, Quantitative estimation of protein and nucleic acids concentration by UV-absorption method,Effect of substrate concentration and determination of Michaelis–Menten parameters V_{max} & K_m, Separation of amino acids by Thin layer chromatography, Determination of molecular weight of a protein by SDS-PAGE.

Readings:

1. Keith Wilson and John Walker, Practical Biochemistry: Principles and Techniques, 5th Edition, Cambridge University Press,2000
2. Pallab Basu, Biochemistry Laboratory Manual,3rd Edition, Academic Publishers,2018
3. J.Jayaraman, Laboratory Manual in Biochemistry, New age International,2011

BT206	MICROBIOLOGY LABORATORY	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT101 Engineering Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Study morphology of microorganisms using compound microscope
CO2	Isolate, culture and preserve microorganisms using aseptic techniques
CO3	Identify and characterize the given microorganism using biochemical tests
CO4	Study the growth characteristics of microorganisms
CO5	Perform physical and chemical aseptic techniques to control microbial growth
CO6	Estimate the nutrient uptake by the microorganisms

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	2	-	-	2	-	-	-	3	-	-
CO2	3	2	-	-	-	2	-	2	-	-		2	2	2	3	2	1
CO3	3	2	-	2	-	-	-	2	-	2	2	-	2	2	3	1	1
CO4	3	2	-	2	-	-	-	1	-	1	-	2	2	2	3	1	1
CO5	3	3	-	2	-	1	-	-	-	2	2	2	2	2	3	-	2
CO6	3	3	-	2	-	-	-	1	-	-	-	-	2	2	3	-	-

Detailed Syllabus:

Detailed Syllabus:

Compound Microscope, Preparation of culture Media, Identification of Microorganisms- Staining Techniques, Culturing of Microorganisms- Pure culture techniques, Isolation of Pure bacteria culture from soil, Spectrometric characterization of microbial growth, Control of microorganism-physical and chemical agents, Estimation of nutrient uptake rate by the microbes.

Reading:

1. James G. Cappuccino and Natalie Sherman, Microbiology: A Laboratory Manual, 10th Edition, Pearson, 2013

BT207	CELL BIOLOGY LABORATORY	PCC	0-0-3	2 Credits

Prerequisites: BT101- Engineering Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Study the cell morphology using microscopic techniques
CO2	Calculate the cell concentration using haemocytometer in unit volume
CO3	Determine cell viability using membrane permeability assay
CO4	Identification of cellular components using various labelling techniques
CO5	Distinguish different stages of Mitotic cell division
CO6	Understand Cell culture techniques

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	3	-	-	-	3	-	-	-	3	-	-
CO2	-	-	-	-	3	-	-	-	3	-	-	-	3	-	-
CO3	-	-	-	-	-	-	-	-	3	-	-	-	3	-	-
CO4	-	-	-	-	3	-	-	-	3	-	-	-	3	-	-
CO5	-	-	-	-	-	-	-	-	3	-	-	-	3	-	-
CO6	1	-	-	-	-	-	-	-	3	-	-	-	3	-	-

Detailed Syllabus:

Demonstration of microscopy, Separation of RBCs, WBCs and microscopic examination, Determining the cell concentration using haemocytometer, Smear preparation and staining (Bacteria, Animal and Plant cells), Cell division – Mitosis, Microscopic determination of cell viability using membrane permeability assay, Luminescent labelling and microscopic detection of cellular components (Direct& Indirect labelling), Demonstration of Cell culture techniques.

Reading:

1. Allyn A. Bregman, Laboratory Investigations in Cell and Molecular Biology, 4thEdition, Wiley, 2001.

MA251	MATHEMATICS IV (Common to EEE, MME, Chemical and Bio-Tech)	BSC	3– 0 – 0	3 Credits

Pre-requisites:

Course Outcomes: At the end of the course, student will be able to:

CO1	Interpret an experimental data using interpolation / curve fitting
CO2	Solve numerically algebraic/transcendental and ordinary differential equations
CO3	Understand the concepts of probability and statistics
CO4	Obtain the series solutions for ordinary differential equations

Mapping of course outcomes with program outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4				`								

Numerical Methods: Curve fitting by the method of least squares. Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves - Gauss-Seidal iteration method to solve a system of equations - Numerical solution of algebraic and transcendental equations by Regula-Falsi method and Newton-Raphson's method - Lagrange interpolation, Forward and backward differences, Newton's forward and backward interpolation formulae - Numerical differentiation with forward and backward differences - Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule - Taylor series method, Euler's method, modified Euler's method, 4th order Runge-Kutta method for solving first order ordinary differential equations (16)Probability and Statistics: Random variables, discrete and continuous random variables, Mean and variance of Binomial, Poisson and Normal distributions and applications. Testing of Hypothesis – Null and alternate hypothesis, level of significance and critical region-Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means - F-test for comparison of variances, Chi-square test for goodness of fit - Karl Pearson coefficient of correlation, lines of regression and examples (16). Series Solution: Series solution of Bessel and Legendre's differential equations - Bessel function of first kind, Recurrence formulae, Generating function, Orthogonality of Bessel functions - Legendre polynomial, Rodrigue's formula, Generating function, Recurrence formula, Orthogonality of Legendre polynomials (10)

Reading:

1. M. K. Jain, S.R.K.Iyengarand R.K.Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.
2. S.C.Gupta &V.K.Kapoor, Fundamentals of Mathematical Statistics, S.Chand & Co, 2006.
3. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
4. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2009.

BT251	TRANSPORT PHENOMENA IN BIOPROCESSSYSTEMS	PCC	3 – 1 – 0	4 Credits

Pre-requisites:BT201 Biochemical Thermodynamics, BT101 Engineering Biology, PH101 - Physics

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand various laws in momentum transfer, types of fluids, viscosity and measurement
CO2	Understand isothermal system, mixing mechanisms and power requirement for Newtonian and Non-Newtonian fluids
CO3	Understand the mechanisms of heat transfer in a stirred tank reactor
CO4	Understand diffusion properties, film theory concepts and mass transfer between various states

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-
CO2	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-
CO3	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-
CO4	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-

Detailed Syllabus:

MOMENTUM TRANSPORT-I: Mechanism of Momentum Transport: Newton's Law of Viscosity, Non- Newtonian fluids, theory of viscosity of liquids, time dependent viscosity, rheological properties of fermentation broth, factors affecting broth viscosity (cell concentration, cell morphology, osmotic pressure, product and substrate concentration),Velocity distribution in laminar flow and turbulent flow. MOMENTUM TRANSPORT-II: Equation of change for isothermal system (equation of continuity, equation of motion), interphase transport in isothermal systems (friction factors for flow in tubes and in packed columns) mixing, mixing mechanism, power requirements in un-gassed Newtonian and Non Newtonian fluids, gassed fluids, interaction between cell and turbulent Eddies, operating conditions for turbulent shear damage. Macroscopic Balances- mass, momentum and mechanical energy balances. ENERGY TRANSPORT: Thermal conductivity and the mechanisms of energy transport- measurement of thermal conductivity, Fourier's law, steady state conduction, analogy between heat and momentum transfer. Temperature distribution with more than one independent variables- heating in a semi-infinite and finite slab, temperature distribution in turbulent flow-reference to stirred tank reactor, relationship between heat transfer, cell concentrations and stirring conditions. MASS TRANSPORT: Diffusivity, theory of diffusion, analogy between mass heat and momentum transfer, role of diffusion in bioprocessing, film theory, concentration distribution with more than one independent variable- unsteady diffusion, boundary layer theory, concentration distribution in turbulent flow- Corrosion equation. Definition of binary mass transfer coefficients, transfer coefficients at high mass transfer rates-boundary layer theory, penetration theory. Convective mass transfer, Liquid -solid mass transfer, liquid-liquid mass transfer, gas-liquid mass transfer. OXYGEN TRANSPORT: Oxygen uptake in cell cultures, Factors affecting cellular oxygen demand, oxygen transfer from gas bubbles to aerobic culture, oxygen transfer in fermenters, bubbles factors affecting oxygen transport- sparging, stirring, medium properties, antifoam agents, temperature, mass transfer correlations, measurements of kLa-oxygen balance method, dynamic method.

Reading:

1. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley, 2006.
2. P. M. Doran, Bioprocess Principles, 2nd Edition, Academic Press, 2012.
3. Harvey W. Blanch and Douglas S. Clark, Biochemical Engineering, 3rd Edition, CRC Press, 2014.
4. Michael L. Shuler, Fikret Kargi and Matthew DeLisa, Bioprocess Engineering: Basic concepts, 3rdEdition, Prentice Hall, 2017.

BT252	BIOPROCESS CALCULATIONS	PCC	3– 0 – 0	3 Credits

Prerequisites: CY101 Chemistry; BT101 Engineering Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the material and energy balances of bioprocesses
CO2	Perform material and energy balances on biochemical processes/equipment without and with reactions
CO3	Perform unsteady state material and energy balances
CO4	Draw the flow diagram and solve the problems involving recycle, purge and bypass in a process or unit

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	2	-	-	3	3	-	3	-	-	-	3	-	-
CO2	-	-	3	2	-	-	1	-	1	-	-	-	3	2	-
CO3	-	-	3	2	-	-	1	-	1	-	-	-	3	-	-
CO4	3	-	3	-	-	-	-	-	-	2	-	-	3	3	2

Detailed Syllabus:

Steady-state material balances: General material balance equations; procedure for material balance calculations; material balances involving multiple sub-systems; simplifications for steady-state processes without chemical reaction; material balance problems with chemical reactions. Material balance for various unit operations: Concept of limiting; excess reactants; fractional conversion; percentage of conversion; percentage yield; excess air calculations; material balances involving simultaneous equations; material balances involving recycle; by-pass; and purge streams; stoichiometry of microbial growth and product formation. Recycle by-pass and Purge: material balances involving recycle; by-pass; and purge streams, Uses of recycle and purge streams, Problems involving recycle and purge streams. Steady-state energy balances: General energy balance equations; enthalpy calculation procedures; enthalpy change in non-reactive processes; steam tables; procedure for energy balance calculations without reaction; energy balance worked examples without reaction; enthalpy change due to reaction. Solving simultaneous material and energy balances. Heat of reaction for processes with biomass production; Energy balance equation for cell culture; fermentation energy balances worked examples. Introduction to unsteady-state material and energy balances: Unsteady-state material and energy balance equations; solving differential equations; unsteady-state mass balances; unsteady-state energy balances; unsteady-state material and energy balances on non-reactive process; heat of mixing and solution; balances on reactive processes; integrated balances.

Reading:

1. Himmelblau, D.H, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall India, 2003.
2. Bhatt B.I, and Vora S.M, Stoichiometry, 4th Edition, Tata McGraw-Hill, 2005.
3. Hougen, O.A, Watson, K.M and Ragatz R.A, Chemical Processes Principles (Part-1): Material and Energy Balances, 2nd Edition, Asia Publication House, 2001.

BT253	MOLECULAR BIOLOGY AND GENETICS	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT202-Biochemistry, BT203-Microbiology, BT204 – Cell Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the structure of nucleic acids & proteins and their interactions
CO2	Understand the mechanisms of central dogma of life
CO3	Study the molecular mechanisms of gene regulation in prokaryotes and eukaryotes
CO4	Understand Mendelian inheritance
CO5	Calculate recombinant frequencies and construct pedigree analysis
CO6	Study chromosomal aberrations in eukaryotes

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	-	3	2	-	-	-	-	-	-	-	2	-	-
CO2	3	-	-	-	2	-	-	-	-	3	-	-	3	-	1
CO3	3	-	2	-	3	-	-	-	-	-	-	-	3	2	-
CO4	3	-	-	3	-	-	-	-	-	2	-	-	3	2	2
CO5	3	2	-	-	3	-	-	-	-	2	-	-	3	-	3
CO6	3	-	-	2	1	1	-	-	-	-	-	-	3	-	2

Detailed Syllabus:

Genome Anatomies: Anatomy of Eukaryotic Genome, unusual chromosomal types, Eukaryotic Organelle genomes, Anatomy of Prokaryotic Genome. Genome Replication: DNA Replication mechanisms, issues relevant to genome Replication, topological problem, diverse function of DNA Topoisomerase, Genetic Recombination, DNA repair processes.

Initiation of Transcription: first step in Gene Expression, Accessing Genome, Assembly of Transcription Initiation Complexes of Prokaryotes and eukaryotes, Regulation of Transcription Initiation. RNA processing: Processing of mRNAs, Synthesis and processing of Non-coding RNAs, Process of pre-RNA by chemical modification, turnover of mRNAs.

Translation**:** Role of tRNA and ribosome in protein synthesis, Post translational processing of proteins. Gene regulation: Regulation of gene expression in Eukaryotes and Prokaryotes, Concept of operon structure. Mechanisms of control of Lac and Trp operons.

Mendelian Genetics**:** Principles, Segregation, Independent Assortment, Dominance Relations and Multiple Alleles, Epistasis, Sex Determination and Sex Linkage. Linkage**:** Linkage symbolism, Linkage of Genes on the X Chromosome, Linkage maps, Crossing Over, Chromosomal mapping, Chromosome Variation in Number, Change in Chromosome Structure, Extra Chromosomal Inheritance.

Reading:

1. Bruce Alberts, Molecular Biology of the Cell, 5th Edition, Garland Science, 2007.
2. David Freifelder, Molecular Biology, 2nd Edition, Narosa Publishing House, Reprint 2004
3. T. A. Brown, Genomes 2, 2nd Edition, Garland Science, 2006
4. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, 6th Edition, CSHL Press, 2008.
5. Strickberger M.W., Genetics, 3rd Edition, Prentice Hall India, 2008

BT254	Biocomputing	PCC	3-0-0	3 Credits

Prerequisites: CS101-Problem Solving & Computer Programming, BT101-Engineering Biology
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the scripting language procedures
CO2	Understand the programming structures, file handling and file management
CO3	Write basic programs in Python, R and more on usage
CO4	Understand the basics of SQL

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	1	-	-	-	-	1	1	2	1	3	2	-
CO2	3	2	2	3	1	-	-	-	1	1	2	1	3	1	-
CO3	3	3	3	3	3	-	-	-	2	2	1	1	3	1	-
CO4	3	3	3	3	3	-	-	-	1	2	2	1	3	1	-

Detailed Syllabus

Introduction to python, history of python, python features, python development tools, writing python program, values and variables; numeric values, variables and assignment, identifiers, controlling the print function. Expressions and arithmetic; operator precedence and associativity, comments, errors (syntax, run-time errors, logic errors), arithmetic examples, conditional execution; simple if statement, if/else statement, conditional expressions.

Introduction to R, R-studio, installation procedures, basic objects; numeric, logical, character, sub setting, named vectors, converting vectors, arithmetic operators for numeric vectors. Creating a matrix, naming rows and columns, sub setting a matrix, creation of array, creation of lists, named lists, creation of data frames. Handling the input, output variables, simple program in R, object oriented programming in R.

Introduction to SQL, role of SQL, SQL Features and Benefits, creation of Simple Database, Retrieving Data, Summarizing Data, Adding Data to the Database, Deleting Data, Updating the Database, Protecting Data, SQL Basics ; Statements, Names, Table Names, Column Names, Data Types, Constants, Numeric Constants, String Constants, Date and Time Constants, Symbolic Constants, Built-In Functions, Missing Data (NULL Values), execution of Queries.

Readings:

1. Jason M. Kinser, Python for Bioinformatics, Jones and Bartlett Publishers, 2009
2. Kun Ren, Learning R Programming, Packt Publishing Limited, 2016
3. James R Groff, Paul N. Weinberg and Andy Oppel, SQL: The Complete Reference, 3rd Edition McGraw-Hill Education, 2009
4. Efficient R Programming: A Practical Guide to Smarter Programming By Colin Gillespie, Robin Lovelace. "O'Reilly Media, Inc."
5. R Programming for Bioinformatics By Robert Gentleman, CRC Press .
6. Richard L., Halterman, “Learning to Program with Python”, 2011.

BT255	Transport Phenomena in Bioprocess Systems Lab	PCC	0 – 0 – 3	2 Credits

Pre-requisites: PH101.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Estimate viscosity of fluids with viscometer and terminal velocity experiment.
CO2	Understand & distinguish laminar and turbulent flows.
CO3	Understand conduction, convection and radiation.
CO4	Determine diffusion coefficient in gases.

Mapping of Course Outcomes (COs) and the Program Outcomes (POs)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-
CO2	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-
CO3	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-
CO4	2	-	-	1	-	1	2	3	-	1	-	-	3	-	-

Detailed Syllabus:

1. Determination of viscosity using Cannon Fenske Viscometer
2. Reynolds Experiment.
3. Verification of Bernoulli's Principle.
4. Electrical Analogue of Heat Conduction.
5. Heat Conduction through Slabs in Series.
6. Heat Conduction in Thin Rod.
7. Natural Convection from a Heated Vertical Cylinder.
8. Pin – Fin Apparatus.
9. Double Pipe Heat Exchanger.
10. Emissivity Measurement Apparatus.
11. Stefan tube experiment to determine diffusion coefficient in gases,
12. Determination of diffusion coefficient in liquids, Diffusion of naphthalene into air
13. Batch distillation

Reading:

Lab manual

BT256	MOLECULAR BIOLOGY AND GENETICS LABORATORY	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT205-Microbiology Lab., BT204-Biochemistry Lab.

Course Outcomes: At the end of the course the student will be able to:

CO1	Demonstrate safe laboratory practices and handle the equipment safely
CO2	Isolate nucleic acids from biological samples.
CO3	Estimate the quality and quantity of nucleic acids using Gel-electrophoresis and spectrophotometer.
CO4	Determine the molecular weight of a given nucleic acid fragment
CO5	Demonstrate blotting and hybridization techniques
CO6	Demonstrate manual sequencing of nucleic acids

Mapping of the Course Outcomes with Program Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	3	-	-	-	2	2	3	-	3	-	-	3	-	-
CO2	2	3	-	3	2	-	-	-	-	-	-	-	3	-	-
CO3	-	3	1	3	2	-	-	-	-	-	-	-	3	-	-
CO4	2	3	-	2		-	-	-	-	-	-	-	3	-	-
CO5	2	3	-		3	-	-	-	-	-	-	-	3	-	-
CO6	2	3	-	2	3	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:

Isolation of Plasmid by Alkali Lysis Method, Isolation of Genomic DNA from Bacteria by High Salt Method, Molecular weight determination of Nucleic acid, Manual Sequencing, DNA Elution from Agarose Gel, Isolation of Genomic DNA from Blood Cells by High Salt Method, Isolation of genomic DNA from Plant Tissue, Isolation of RNA from Yeast, Southern Blotting, Southern Hybridization

Reading:

1. Laboratory manual
2. Molecular cloning: A Laboratory Manual (3rd Edition) by Joseph Sambrook and David Russell, CSHL Press, 2004.

BT257	**Biocomputing lab**	PCC	0-0-2	2 Credits

Pre-requisites: CS101-Prob. Solving & Computer Programming

Course Outcomes: At the end of the course the student will be able to:

CO1	Apply their programming skills to write and execute simple programs in python and R
CO2	Apply their programming skills to creating applications
CO3	Apply the concept of exception handling mechanism and to handle exceptions while programming
CO4	Apply above programming skills to analyze biological data

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	-	-	-	2	1	1	1	3	1	-
CO2	3	3	3	2	2	-	-	-	1	1	1	1	3	1	-
CO3	3	3	3	2	2	-	-	-	1	1	1	1	3	1	-
CO4	3	3	2	3	3	-	-	-	1	1	1	1	3	1	-

Detailed Syllabus:

1. Program for creation of bio-data base with fields
2. Program for record manipulations such as deletion, modification, addition and counting the record.
3. Program to perform arithmetic calculations in python
4. Program for creating table to demonstrate simple biological application -I
5. Program for creating table to demonstrate simple biological application -II
6. Program to find the length of the given sequence
7. Program to reverse and concatenation of the given sequence
8. Program to complement and reverse complement of DNA sequence
9. Program to calculate GC content in the given DNA sequence
10. Program to translate DNA into Protein Sequence

Text books:

1. C. J. Date, A. Kannan, “Database Systems”, Pearson Education Publication
2. Martin C Brown, “Perl The Complete Reference”, Second Edition, Tata McGraw Hill, 2001
3. Jason Kinser, “Python for Bioinformatics”, Jones and Bartlett Publishers, Sudbury, Massachusetts 2009

BT301	BIOPROCESS ENGINEERING	PCC	3 – 1 – 0	4 Credits

Prerequisites: BT252 Bioprocess calculations, BT201Biochemical Thermodynamics

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the roles and responsibilities of a bioprocess engineer.
CO2	Understand sterilization techniques and estimate the sterilization time
CO3	Understand the rheology of fermentation fluids and determine the power requirement in bioreactors
CO4	Develop the design equations for bioreactors and calculate the oxygen demand for cell growth.
CO5	Understand the scale up concepts for bioprocesses.
CO6	Identify sensors and instruments needed for measurement and control.

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	-	2	-	-	-	-	-	-	-	-	3	2	-
CO2	3	3	-	3	-	-	-	-	-	-	-	-	3	-	-
CO3	-	3	2	3	-	-	-	-	-	-	-	-	3	-	-
CO4	2	3	-	3	-	-	-	-	-	-	-	-	3	-	-
CO5	1	3	3	3	-	-	-	-	-	-	-	-	3	3	-
CO6	1	3	3	3	-	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:

Introduction: Role of a bioprocess engineer, Kinetics of microbial growth, substrate utilization and product formation; Simple structured models, Design of fermentation media.

Sterilization: Media sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, sterilization of air and filter design, Radiation and chemical sterilization.

Batch, fed-batch and continuous processes: Operation of batch, continuous and fed-batch processes and industrial applications, Comparison of batch, fed-batch and continuous processes.

Rheology of fermentation fluids: Newtonian and non-Newtonian fluids, Aeration and agitation, power requirement for gassed and un-gassed systems, time calculation for mixing.

Mass transfer in bioreactors: Theories of mass transfer, metabolic oxygen demand, measurement of K_La, Maximum cell concentration.

Instrumentation in bioreactors: On-line and off-line measurement various types of microbial and enzyme reactors, Bioreactor Considerations for Animal Cell Culture and plant cell culture.Fermentation: Structured and Unstructured Models, Optimization of Fermentation media.

Reading:

1. Bioprocess Engineering Principles. By Paulin M. Doran. Elsevier Science & Technology Books, 2008.
2. Biochemical Engineering Fundamentals, Second Edition, James E. Bailey, David F. Ollis. Mc Graw Hill, 2004.
3. Bioprocess Engineering Basic Concepts 2nd Edition, Michael Shuler, Fikret Kargi. Prentice-Hall India, 2006.
4. Bioprocess Engineering: Kinetics, Mass Transport, Reactors and Gene Expression by Wolf. R. Vieth. A Wiley-Inter science Publication, 2009.
5. "Principles of fermentation technology" P F Stanbury and A Whitaker, Pergamon press, 2005.

BT302	BIOLOGICAL REACTION ENGINEERING	PCC	3 – 1 – 0	4 Credits

Prerequisites: BT252 Bioprocess calculations, BT201Biochemical Thermodynamics

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the kinetics and mechanism of chemical and biochemical reactions
CO2	Classify bioreactors
CO3	Estimate Monod's parameters
CO4	Develop models for bioreactors and structured models for microbial growth
CO5	Design batch, continuous flow, and fed batch reactors for enzymatic reactions
CO6	Understand scale up concepts for bioreactors

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	1	3	-	-	-	-	-	-	-	3	1	-
CO3	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
CO4	3	-	-	2	3	-	-	-	-	-	-	-	3	-	-
CO5	3	-	-	2	3	-	-	-	-	-	-	-	3	3	-
CO6	3	-	-	1	3	-	-	-	-	-	-	-	3	2	-

Detailed Syllabus:

Introduction**:** From Bioprocess design to system biology, Types of reaction, order of reaction. The effect of temperature on reaction rate. Rate equations and Reaction mechanisms; Interpretation of batch reactor data, constant volume batch reactor, integral method of analysis of data for reversible and irreversible reactions.

Bioreactor systems**:** Definitions, Differences and similarities between chemical and bioreactors; Classification of bioreactors; Reactor configurations; Description of a conventional bioreactor with all aspects; Design and construction criteria of a bioreactor; Residence time distributions, concentration, and temperature distributions; Models of non-ideal reactors, Imperfect mixing.

Design of Bioreactors**:** Design equations for enzyme reactors, batch growth of microorganisms, Design equation of a plug flow reactor; Design of CSTR with washout concept; Stirred tank reactors with recycle of biomass; Continuous stirred tank fermenter in series without and with recycle of biomass; Estimation of kinetic parameters.

Modeling of growth kinetics and design of fermentation processes: Model structure and complexity, a general structure for kinetic models, unstructured growth kinetics, Simple structured models, Mechanistic models, morphologically structured models, the stirred tank bioreactor, plug flow reactor, Dynamic analysis of continuous stirred tank bioreactors.

Reading:

1. Bioreaction Engineering Principles , Second Edition, Jens Nielsen , John Villadsen , Gunnar Lidén .Kluwer Academics /Plenum publishers, 2002.
2. Chemical Reaction Engineering; third Edition, Octave Levenspiel A Wiley- interscience Publication, 2004.
3. Bioprocess Engineering Principles. Paulin M. Doran. Elsevier Science & Technology Books, 2006.
4. Biochemical Engineering Fundamentals, Second Edition, James E.Bailey, David F. Ollis. Mc Graw Hill, 1989.

BT303	IMMUNOLOGY	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT101 Engineering Biology, BT253 Molecular Biology & Genetics
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand innate and adaptive immune responses.
CO2	Understand the role of primary and secondary lymphoid organs.
CO3	Understand antigen and antibody interactions
CO4	Understand the mechanism of immunization
CO5	Understand the role of immune system in organ transplantation, autoimmune disorders and Cancer

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	-	2	-	-	-	-	-	2	-	-	2	-	-
CO2	3	2	-	1	-	-	-	-	-	2	-	-	2	-	-
CO3	3	3	-	3	-	-	-	-	-	2	-	-	3	2	-
CO4	3	3	2	3	-	3	-	2	-	3	2	3	2	3	3
CO5	3	3	3	3	-	-	-	-	-	3	-	2	3	2	3

Detailed Syllabus:

Introduction to Immune System, Types of immunity: Innate & Adaptive Immunity, Cells and components of Immune system, Organs of Immune system: Primary lymphoid organs: Structure and Functions, Secondary lymphoid organs: Structure and Functions

Immunogen, Haptens & Adjuvants, Epitope, Immunoglobulin Structure, Immunoglobulin Isotypes: Structure and Functions, Monoclonal Antibodies: Hybridoma Technology and Applications, Recombinant & Chimeric Antibodies, Humanized & Bispecific Antibodies, Immunotoxins, Polyclonal antibodies, Abzymes, Antigen-antibody interactions: Agglutination, Precipitation, Immuno diffusion, ELISA, Immuno electrophoresis.

Organization and Expression of Immunoglobulin genes: Antibody Diversity: Somatic variation theory, Germ line theory, Tonegawa's bombshell: Immunoglobulin genes rearrange, Immunoglobulin Light chain (Kappa, Lambda) rearrangement, Immunoglobulin Heavy chain rearrangement, Immunoglobulin Class Switching, B-cell Maturation & activation by TI and TD antigens, T Lymphocyte development and activation: Cell mediated cytotoxic responses, MHC: Structure and Functions

Complement system, Hypersensitivity reactions, Cytokines, Immunological tolerance, Auto immune disorders

Transplantation, Graft rejection & Immunosuppressive Therapy, Vaccines: Types of Vaccines, Tumor Immunology

Reading:

1. R.A. Goldsby, Thomas J. Kindt, Barbara, A. Osbarne (Freeman), Kuby Immunology, 6th Edition, 2007.
2. Abul K Abbas, Andrew H. Lichtman, Shiv Pillai, Cellular & Molecular Immunology, 7th Edition, 2011.
3. Peter J Delves, S. J. Martin, I. M. Roitt, Roitt's Essential Immunology, 12th Edition.

BT304	Genetic Engineering	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT202 Biochemistry, BT203Microbiology, BT253 Molecular Biology & Genetics
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand basic and advanced techniques in Genetic Engineering.
CO2	Select appropriate host and vector system for cloning and expression.
CO3	Understand the cloning strategies and expression of recombinant molecules.
CO4	Understand the gene regulation mechanism in bacteria and eukaryotic hosts.
CO5	Apply genetic engineering principles for biotechnological and biomedical applications.

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	-	2	1	-	-	1	-	-	-	-	3	1	2
CO2	-	3	3	3	2	-	-	2	-	-	-	-	3	2	2
CO3	-	3	3	3	2	-	-	-	-	-	-	-	3	1	1
CO4	3	3	-	1	-	-	-	-	-	-	-	-	3	-	-
CO5	1	2	3	3	-	2	-	-	-	-	1	2	3	2	2

Detailed Syllabus:

Basic Techniques: Agarose gel electrophoresis, Nucleic acid blotting, transformation of *E. coli,* Advance Techniques in gene expression and analysis, PCR, RT-PCR, Real Time PCR, micro array, gene chip, Hybridization - Radio labeling, FISH - Fluorescent in situ hybridization, mFISH, gene tagging, DNA finger printing.

Cutting and joining DNA molecules: various restriction enzymes, ligases, joining DNA molecules, Cloning Vectors: Plasmids and Phage Vectors, Cosmids, Phasmids and other advanced vectors. Cloning strategies and DNA libraries: Introducing DNA into bacterial cells, cloning in Gram negative bacteria other than *E.coli*, Gram positive bacteria, *Saccharomyces cerevisiae* and other fungi, gene transfer to animal and plant cells, gene transfer by viral transduction.
cDNA cloning, genomic libraries, screening of libraries and recombinant clone selection, hybridization with differential expression and subtractive techniques.

Sequencing and Mutagenesis: Basic DNA sequencing, whole genome sequencing, analyzing sequence data, chromosome walking, short gun sequencing, concept of next generation sequencing technology, changing genes – site directed mutagenesis, reverse mutagenesis, cassette mutagenesis. Molecular markers: RFLP, RAPD, AFLP, gene knockout gene mapping.
Advances and applications: Transgenic and Recombinant DNA Technology: Inducible expression system, Prokaryotic and eukaryotic expression systems, transgenic animals and plants, molecular pharming.

Reading:

1. Old RW and Primrose SB.Sixth edition, “Principles of gene manipulation ", BlackWell Scientific Publications, 2001.
2. Bernard R. Glick and Jack J. Pesternak. Third edition, “Molecular Biotechnology: Principles and Applications of recombinant DNA”, American Society for Microbiology, 2003.

BT305	BIOSTATISTICS	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT251 Mathematics-IV
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the mathematical basis and foundations of probability and statistics
CO2	Apply statistical methods to solve biological problems
CO3	Use basic and modern statistical software to analyze the big data in biology and clinical data

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	-	-	-	3	-	-	-	-	1	-	2	3	-	1
CO2	3	-	-	-	-	-	-	-	2	-	-	1	3	-	-
CO3	3	2	-	-	3	-	-	2	-	-	-	1	3	2	-

Detailed Syllabus:

Introduction to biostatistics and organization of data, data type, graphical and pictorial presentation of data, measurers of central tendency and dispersion, sampling techniques, sample size, coefficient of variation, means error, relative error, precision and accuracy.

Introduction to probability, Bayes' theorem, probability distributions, binomial distribution, poison distribution, normal distribution. Parametric and Non-parametric tests: Testing hypothesis, types of errors, tests of significance based on normal distribution, Data characteristics and nonparametric procedures, chi square test, sign test, Wilcoxon sign rank test, ANOVA, linear and multiple regression and correlation, method of least squares, significance of correlation and regression. Test of significance for correlation coefficients.

Experimental design, Randomization, completely randomized and Latin square designs, factorial design, cross over and parallel designs.

Statistical machine learning, Introduction to Big data analytics, data analytics lifecycle: discovery, data preparation, model planning, model building, communicate results, operationalize, applied data science with R.

Reading:

1. Daniel Wayne W., Biostatistics: A Foundation for Analysis in the Health Sciences, 9th Ed., John Wiley & Sons, 2008.
2. Rosner Bernard, Fundamentals of Biostatistics, 7th Ed., Brooks/Cole, 2011.
3. Motulsky H, Intuitive Biostatistics, 2nd Ed., Oxford University Press, 2009.
4. Data Science and BIg Data Analytics. Discovery, Analyzing, Visualizing and Presenting Data, EMC Education Services, John Wiley & Sons, 2017.

BT306	BIOPROCESS ENGINEERING LABORATORY	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT301 Bioprocess Engineering

Course Outcomes: At the end of the course the student will be able to:

CO1	Estimate MM constants
CO2	Find the effect of pH and temperature on enzyme activity
CO3	Estimate the Monod parameters in batch, fed-batch and continuous cultures
CO4	Estimate residence time distributions in batch and continuous bioreactors

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	-	-	-	-	-	-	-	-	-	3	-	-
CO2	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO3	2	3	1	-	-	-	-	-	-	-	-	-	3	1	-
CO4	2	3	1	-	-	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:

Growth kinetics of bacteria in Fed-Batch Reactor, Enzyme Immobilization, Microbial death Kinetics, Residence time distribution, fluidized bed bioreactor for cell cultivation, determination of mixing time and power number in chemostat, effect of temperature, pH substrate concentration on enzyme activity, inhibition kinetics and estimation of biomass.

Reading:

1. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2008.

BT307	IMMUNOLOGY LABORATORY	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT101 Engineering Biology, BT256 Molecular Biology lab.

Course Outcomes: At the end of the course the student will be able to:

CO1	Perform single and double diffusion techniques to analyze antigen – antibody interactions
CO2	Separate immune globulins using immune electrophoresis
CO3	Detect the antigen / antibody sample using ELISA test
CO4	Estimate the concentration of the antigen / antibody sample using quantitative precipitin assay
CO5	Immunodiagnostics using latex / hemagglutination test

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	-	2	-	-	1	-	3	-	2	-	3	3	-
CO2	3	1	-	2	-	-	-	-	3	-	2	-	3	3	-
CO3	3	2	2	2	2	2	-	-	3	-	2	-	3	3	-
CO4	3	1	2	2	-	2	-	-	3	-	2	-	3	3	-
CO5	3	2	2	2	-	3	1	3	3	-	2	2	3	3	3

Detailed Syllabus:

Antigen-antibody interactions - Ouchterlony double diffusion, Radial immune diffusion, Estimation of antigen / antibody concentration - Quantitative precipitin assay, Separation of Immuno globulins – Immuno electrophoresis, Rocket immune electrophoresis, Countercurrent immune electrophoresis, Immunodiagnostics - Widal test, Latex agglutination, Blood group test, Detection of given antigen / antibody samples - ELISA.

Reading:

1. R.A. Goldsby, Thomas J. Kindt, Barbara, A. Osbarne (Freeman), Kuby Immunology, 6th Edition, 2007.
2. Abul K Abbas, Andrew H. Lichtman, Shiv Pillai, Cellular & Molecular Immunology, 7th Edition, 2011.
3. Peter J Delves, S. J. Martin, I. M. Roitt, Roitt's Essential Immunology, 12th Edition.

BT308	Genetic Engineering Laboratory	PCC	3 – 0 – 0	2 Credits

Prerequisites: BT206Microbiology lab, BT256 Molecular Biology& Genetics lab

Course Outcomes: At the end of the course the student will be able to:

CO1	Demonstrate basic safe laboratory practices and set up laboratory equipment safely
CO2	Manipulate nucleic acids employing basic laboratory techniques and use standard procedures to clone them.
CO3	Plan and execute the genetic engineering experimental procedures, interpret data and report the experimental data and results

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	-	1	3	-	-	1	3	-	2	1	3	1	3
CO2	3	3	3	3	3	-	-	2	3	-	1	1	3	1	3
CO3	3	3	3	3	3	-	-	-	3	-	3	1	3	1	3

Detailed syllabus:

Preparation of competent cell, Transformation of plasmid DNA into competent cell, Restriction Digestion of DNA fragment with Restriction enzymes, DNA Ligation, Amplification of DNA fragment by PCR, Green Florescence Protein (GFP) Cloning and Expression, Transformation of cloned plasmid into bacterial host cells & blue white Screening, RAPD/RFLP/AFLP, *invitro* transcription.

Reference Books:

1. Molecular cloning: A Laboratory Manual (3rd Edition) by Joseph Sambrook and David Russell, CSHL Press, 2004.

BT351	BIOSEPARATION TECHNOLOGY	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT201 Biochemical Thermodynamics

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand separation techniques used in downstream process
CO2	Design and optimize downstream processes
CO3	Understand the requirements for successful operation of downstream processes
CO4	Understand the principles of major unit operations used in downstream processing of biopharmaceuticals.

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	-	3	2	-	1	-	-	-	-	-	-	-	-	-
CO2	2	-	3	-	-	-	-	-	-	1	-	-	2	-	-
CO3	3	-	-	-	2	-	-	1	-	-	2	-	-	1	-
CO4	3	2	-	-	2	-	-	-	-	-	-	1	-	-	1

Detailed Syllabus:

Scope of Downstream Processing: Importance of Down Stream Processing (DSP) in biotechnology, microbial protein expression and purification. Characteristics of products, criteria for selection of bio-separation techniques. Role of DSP methods in bioprocess economics, Cell disruption methods: Various cell disruption methods, need for cell disruption for intracellular products, cell disruption equipment. Applications in bio-processing.

Solid- Liquid separation: Centrifugation: Principles of centrifugation, centrifuge effect, various centrifuges; basket centrifuge, tabular centrifuge, disc-bowl centrifuge, Extraction methods. Concentration of products.

Membrane separation processes: Basic principles of membrane separation, membrane characteristics, different types of membranes, criteria for selection of membranes.

Chromatographic separation and electrophoresis methods: Principles of chromatographic separation methods, different types of chromatographic methods, ion – exchange chromatography, gel chromatography, affinity chromatography etc. Applications in bio-processing. Principles of electrophoresis and electrophoresis mobility, Applications

Drying**:** Various types of drying methods, Freeze drying technique and its advantages over other methods.

Reading:

1. Bioseparations: Downstream Processing for Biotechnology, Paul A. Belter, Wiley-Blackwell, 2008
2. Bioseparations: Principles and Techniques, Sivasankar, Prentice Hall India Learning Private Limited,2005
3. Downstream Process Technology, Prasad, Prentice Hall India Learning Private Limited, 2010.
4. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann, 2010.
5. Principles of Downstream processing, by Ronald & J.Lee, Wiley Publications, 2007.

BT352	BIOPROCESSINSTRUMENTATIONAND CONTROL	PCC	3–1–0	4 Credits

Prerequisites: BT301 Bioprocess Engineering

Course Outcomes: At the end of the course the student will be able to:

CO1	Classify Bioprocess instrumentation for the measurement of pressure, temperature, fluid flow and liquid level.
CO2	Understand the dynamic behavior of bioprocesses
CO3	Analyze different components of a control loop
CO4	Understand the closed loop control system
CO5	Analyze stability of feedback control system

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	3	1	-	1	-	-	1	1	-	1	2	-	-
CO2	2	2	-	1	-	1	-	-	-	-	-		2	1	-
CO3	3	2	-	1	-	-	-	-	-	-	-	-	2	1	-
CO4	3	2	-	1	-	-	-	-	-	-	-	-	2	1	-
CO5	3	2	-	1	-	-	-	-	-	-	-	-	2	1	-

Detailed Syllabus:

Bioprocess Instrumentation: Temperature, pH, Level, Flow, Pressure, DO sensors. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.

Components of a Control System, Block Diagram, Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems.

Transient response of simple control systems: Servo Problem, Regulatory Problem, Controllers: Proportional, Proportional-Integral, PID Controllers. Ziegler-Nichols Controller Settings. Stability: Routh Test for Stability, Root Locus.

Introduction to frequency Response: Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.

Reading:

1. Donald R.Coughanowr(2009), Process Systems Analysis and Control, Mcgraw-Hill,
2. Eckman, D.P (2007) Industrial Instrumentation. Wiley.
3. Shulerand Kargi(2002), Bioprocess engineering. Prentice Hall.
4. Baileyand Ollis (2006), Biochemical engineering fundamentals. McGrawHill
5. Tarun Ghosh (2004) Biotechnology and bioprocess engineering: Proceedings, VII international biotechnology symposium. Delhi.
6. George Stephanopoulous (2009) Chemical process control, Prentice Hall of India.

BT353	BIOINFORMATICS AND COMPUTATIONAL BIOLOGY	PCC	3 – 1 – 2	5 Credits

Prerequisites: BT202 Biochemistry, BT253 Molecular Biology & Genetics

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the different types of biological databases available in open source domain
CO2	Understand the importance of biological sequence comparison, alignment
CO3	Understand the association between sequence alignment and phylogenetic analysis
CO4	Analyze secondary and tertiary structure of proteins using various tools.
CO5	Comprehend the principles of protein structure modeling and validation

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO2	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO3	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
CO4	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
CO5	3	-	-	2	3	-	-	2	-	-	-	-	3	-	-

Detailed Syllabus:

Historical Introduction and Overview of Bioinformatics, Collecting and Storing Sequences in the Laboratory, Alignment of Pairs of Sequences, Introduction to Probability and Statistical Analysis of Sequence Alignments, Multiple Sequence Alignment, Sequence Database Searching for Similar Sequences. Genome Analysis, Genome organization and evolution, Alignments and phylogenetic trees, Phylogenetic Prediction, Prediction of RNA Secondary Structure, Gene Prediction and Regulation.

Structural bioinformatics and drug discovery, Protein Classification and Structure Prediction, Genome Analysis, Bioinformatics Programming Using Perl and Perl Modules, Analysis of Microarrays, Introduction to systems biology & Metabolic pathways.

Practical: Biological Databases, Pair wise sequence alignments, multiple sequence alignments, ORF/Gene finding, Phylogenetic Tree construction, Protein Structure visualization, Protein modeling, Molecular docking studies, QSAR.

Reading:

1. David W. Mount; Bioinformatics: Sequence and Genome Analysis; CSHL Press; 2nd edition, 2004
2. Arthur Lesk; Introduction to Bioinformatics, Oxford University Press, 4th edition, 2013
3. Andreas D. Baxevanis, Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins. Wiley-Interscience, 3rd edition 2004
4. Andrew Leach; Molecular Modelling: Principles and Applications, 2nd edition, 2001
5. Proteins: Structure and Function 1st edition, 2008

SM335	ENGINEERING ECONOMICS AND ACCOUNTANCY	HSC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Prepare accounting records and summarize and interpret the accounting data for managerial decisions
CO2	Understand the macro-economic environment of the business and its impact on enterprise
CO3	Understand cost elements of the product and its effect on decision making
CO4	Understand the concepts of financial management and smart investment

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1								1	3	2
CO2								1	3	2
CO3								1	3	2
CO4								1	3	2

Detailed Syllabus:

Engineering Economics: Introduction to Engineering Economics – Fundamental concepts – Time value of money – Cash flow and Time Diagrams – Choosing between alternative investment proposals – Methods of Economic analysis. The effect of borrowing on investment- Various concepts of National Income – Significance of National Income estimation and its limitations, Inflation –Definition – Process and Theories of Inflation and measures to control, New Economic Policy 1991 – Impact on industry.

Accountancy: Accounting Principles, Procedure – Double entry system – Journal – Ledger, Trail Balance – Cash Book – Preparation of Trading, Profit and Loss Account – Balance sheet.

Cost Accounting – Introduction – Classification of costs – Methods of costing – Techniques of costing – Cost sheet and preparation of cost sheet- Breakeven Analysis – Meaning and its application, Limitations.

Reading:

1. Henry Malcom Stenar, Engineering Economic Principles, McGraw Hill, 2005.
2. K K Dewett, Modern Economic Theory, Siltan Chand & Co., 2005.
3. Agrawal AN, Indian Economy, Wiley Eastern Ltd, New Delhi, 2012.
4. Jain and Narang, Accounting Part-I, Kalyani Publishers, 2012.
5. Arora, M.N., Cost Accounting, Vikas Publications, 2013.

BT354	BIOSEPARATION TECHNOLOGY LABORATORY	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT202 Biochemistry,

Course Outcomes: At the end of the course the student will be able to:

CO1	Extract intra and extra cellular proteins from biological samples
CO2	Perform cell destruction by sonication and enzymatic methods
CO3	Fractionate proteins using precipitation methods
CO4	Separate proteins using chromatographic techniques
CO5	Analyze the purity of proteins using electrophoresis

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-
CO3	2	1	3	-	-	-	-	-	-	-	-	-	-	1	-
CO4	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1
CO5	2	3	-	2	-	-	-	-	-	-	-	1	-	-	-

Detailed Syllabus:

Extraction of Intracellular Proteins by cell disruption methods, Centrifugation methods, Sonication methods, Precipitation methods, Lyophilization, Ion exchange chromatography, Gel filtration chromatography, Affinity chromatography, Tangential filtration methods, NATIVE electrophoresis, Storage methods for isolated products

Reading:

1. Handbook of Bio separations, Satinder Ahuja, Academic Press,2000
2. Downstream Processing of Proteins: Methods and Protocols, Mohamed A.Desai, Humana Press,2012
3. Protein Purification: Principles and Practice: 3rd Edition, Springer, 2014
4. Practical Biochemistry: Principles and Techniques, John M Walker, Keith Wilson Cambridge University Press,2007

BT354	BIOPROCESSINSTRUMENTATIONAND CONTROL LABORATORY	PCC	0–0–3	2 Credits

Prerequisites: BT306 Bioprocess Engineering Lab

Course Outcomes: At the end of the course the student will be able to:

CO1	Calculate the response of a glass thermometer
CO2	Determine the time constant of a thermocouple
CO3	Determinethedynamicsoftwocapacityliquidlevelprocesswithoutinteractionandwith interaction
CO4	Evaluate the dynamics of a stirred tank reactor
CO5	Determinetheperformanceofcontrollersforaflowprocess,pressureprocess,level process, temperature process, heat exchanger system

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	-	2	-	-	2	2	-	1	3	-	1
CO2	2	2	2	2	-	2	-	-	2	2	-	1	3	-	1
CO3	3	2	2	1	-	2	-	-	2	2	-	1	2	-	1
CO4	3	2	2	1	-	2	-	-	2	1	-	1	2	-	-
CO5	3	2	2	1	-	2	-	-	2	2	-	1	2	-	1

Detailed syllabus:

Interacting and Non-Interacting liquidlevel system, Time constantofa liquid in glass thermometer, Heat transfer dynamics in a stirred tank, computer controlled flow process analyzer (P, PD, PID controls) levels process analyzer, Pressure analyzer, temperature process analyzer, computer controlled heat exchanger.

Department Elective Courses

BT361	PLANT BIOTECHNOLOGY	DEC	3-0-0	3 Credits

Prerequisites: BT204-Cell Biology, BT253 Molecular Biology& Genetics, BT202 Biochemistry, BT304 Genetic engineering.

Course Outcomes: At the end of the course the student will be able to:

CO1	Comprehend the concepts of Plant tissue culture techniques
CO2	Learn In vitro techniques for production of plant secondary metabolites
CO3	Understand the technology of plant transformation
CO4	Study of conventional and molecular marker breeding techniques

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	-	-	3	2	3	-	-	-	1	2	3	-	2
CO2	-	3	-	2	-	-	3	-	-	-	1	2	-	3	2
CO3	-	-	3	-	3	-	3	-	-	-	1	-	-	-	-
CO4	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-

Detailed Syllabus:

Introduction to Plant Biotechnology, Plant agriculture: The impact of biotechnology, Special features and organization of Plant cells, Plant growth hormones: Physiology, Transpiration, Movement of water and ions, translocation of phloem, Phytochromes, Photoperiodism, Florigen, Vernalization.

Plant Tissue Culture, Media, culture conditions, regeneration methods of plants in PT cultures, cell suspension culture, Anther, protoplast, Somatic hybrids and cybrids, Applications of cell and tissue culture, Production of Secondary metabolites, Engineering considerations for production of phytochemicals.

Successful gene transfer mechanism, Direct and Indirect methods, Agrobacterium mediated gene transfer, Applications of Transgenic plants, Insecticidal, herbicidal and viral resistance, Other applications of Transgenic plants.

Transgenic Plant Analysis, Initial screens, Definitive molecular characterization, Field Testing of Transgenic Plants, Environmental risk assessment, why transgenic plants are so controversial, importance of greenhouse in PBT.

Reading:

1. Adrian Slator, Nigel W. Scott and Mark R. Fowler; Plant Biotechnology: the genetic manipulation of plants; Oxford University Press;2008
2. C. Neal Stewart, Plant Biotechnology and Genetics: Principles, techniques and applications; John Wiley and Sons, Inc., Publication, 2008.

3. P.S. Srivastava, Alka Narula and Sheela Srivastava, Plant Biotechnology and Molecular Markers; Springer Science, 2005.
4. H.S. Chawla, Introduction to Plant Biotechnology; Science Publishers, 2004
5. Plant physiology,Lincoln Taiz and Eduardo Zeiger Oxford publishers, 2010.
6. Introduction to Plant tissue culture,second edition by M.K.Razdhan,science publishers,2003

BT362	BIOMASS & BIOFUELS TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT101 Engineering Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify potential biomass sources for renewable energy generation.
CO2	Understand the production process for liquid biofuels.
CO3	Understand the production process of gas, bio hydrogen and electricity
CO4	Differentiate first and second generation biofuels
CO5	Understand the concept of strain improvement for biofuels production
CO6	Forecast the entrepreneurial opportunities in Bioenergy

Mapping of the Course Outcomes with Program Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	3	-	-	-	-	3	-	-	-	-	-	2	2	3
CO2	-	3	-	-	-	-	3	-	-	-	-	-	2	2	3
CO3	-	-	3	-	-	-	3	-	-	-	-	-	2	2	3
CO4	3	-	-	-	-	-	3	-	-	-	-	-	2	2	3
CO5	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3
CO6	3	-	3	-	-	-	3	-	-	-	-	-	2	2	3

Detailed Syllabus:

Introduction to oil economy, working principle of IC engines, Effects of emissions of greenhouse gases and other pollutants, National Biofuel Policy and law, Biomass to Biofuels: An overview. Biomass formation on the earth: photosynthesis; Chemistry and composition of Biomass. Biomass conversion technologies: Pretreatment technologies, Biomass to liquid fuels. Biomass degrading enzymes and microorganisms.

Bioethanol production from lignocellulosic feedstocks, algae and sea weeds. Genetic and metabolic engineering of bacteria and yeast for bioethanol production. Strain engineering for ethanol and inhibitor tolerance.

Vegetable oils and chemically processed biofuels, Biodiesel composition and production processes, Biodiesel economics, Fischer-Tropsch Diesel: Chemical Biomass–to–Liquid Fuel Transformations. Algae Biodiesel; Technical challenges in biodiesels production.

Biomass to gaseous fuel production, Bio hydrogen Production, Microbial Fuel Cells. Concept of Bio refinery: Lignocellulose-Based Chemical Products. Entrepreneurial Opportunities in Bioenergy.

Reading

1. Vijai K. Gupta et al. Bioenergy Research: Advances and Applications Elsevier B.V. Netherlands 119, 2014. ISBN 978-0-444-59561-4.
2. Dahiya, A. (2015). Bioenergy: biomass to biofuels. Paperback ISBN: 9780124079090
3. Vaughn C. Nelson, Kenneth L. Starcher Introduction to Bioenergy (Energy and the Environment) by CRC Press ISBN 13: 978-1-4987-1699-4
4. Vijai K. Gupta et al. Biofuel Technologies-Recent Developments Springer-Verlag Berlin Heidelberg ISBN 978-3-642-34519-7
5. Kazuyuki Shimizu. Metabolic Regulation and Metabolic Engineering for Biofuel and Biochemical Production. ISBN 9781498768375 – CRC Press, 2017
6. David M. Mousdale, Biofuel-Biotechnology, Chemistry, and sustainable Development, 1st Ed., CRC Press Taylor & Francis Group, 2008.
7. Ayhan Demirbas, Green Energy and Technology, Biofuels, Securing the Planet's Future Energy Needs, 1st edition, Springer, 2009.

BT363	ENVIRONMENTAL BIOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT 101 Engineering Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the biological treatment techniques for waste water
CO2	Understand the principle of industrial waste management
CO3	Describe the use of biotechnological processes to protect the environment
CO4	Contrast approaches to anaerobic digestion of wastes and solve related problems

Mapping of the Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	3	-	3	3	-	-	2	-	-	2	-	-
CO2	-	-	2	-	-	2	2	-	-	3	-	-	2	2	-
CO3	1	-	-	-	-	3	3	-	-	1	-	-	2	-	2
CO4	-	-	2	3	-	2	2	-	-	-	-	-	1	-	2

Detailed Syllabus:

Biological Treatment of Wastewater – Aerobic System Biological processes for domestic and industrial waste water treatments; Aerobic systems - activated sludge process, trickling filters, biological filters, rotating biological contractors (RBC), Fluidized bed reactor (FBR), expanded bed reactor, Inverse fluidized bed biofilm reactor (IFBBR) packed bed reactors air- sparged reactors.

Biological Treatment of Wastewater, Anaerobic System Anaerobic biological treatment – contact digesters, packed column reactors, UASB.

Bioremediation: Introduction, constraints and priorities of Bioremediation, Biostimulation of naturally occurring microbial activities, Bioaugmentation, in situ, ex situ, intrinsic & engineered bioremediation. Solid phase bioremediation - land farming, prepared beds, soil piles, Phytoremediation. Composting, Bioventing & Biosparging; Liquid phase bioremediation - suspended bioreactors, fixed biofilm reactors.

Metal Biotechnology Mining and Metal biotechnology – with special reference to Copper & Iron. Microbial transformation, accumulation and concentration of metals, metal leaching, extraction and future prospects.

Hazardous Waste Management: Introduction - Xenobiotic compounds, recalcitrance. Hazardous wastes - biodegradation of Xenobiotics. Biological detoxification - market for hazardous waste management, biotechnology application to hazardous waste management - examples of biotechnological applications to hazardous waste management – cyanide detoxification - detoxification of oxalate, urea etc. - toxic organics – phenols, STP, antibiotic treatment.

Reading:

1. Biodegradation & Bioremediation (2009), Martin Alexander, Academic press.
2. Stanier R. Y., Ingram J.L., Wheelis M.L., Painter R.R., General Microbiology, McMillan Publications, 2009.
3. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., 2007.
4. Karrely D., Chakrabarty K., Omen G.S., Biotechnology and Biodegradation, Advances in Applied Biotechnology Series, Vol.4, Gulf Publications Co. London, 2009.

BT401	MODELLING SIMULATION AND OPTIMIZATION OF BIOPROCESSESS	PCC	3 – 1 – 2	5 Credits

Prerequisites: BT301 Bioprocess Engineering, BT352 Bioprocess Instrumentation & Control

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the Modelling Principles
CO2	Formulate Balance Equations
CO3	Understand and analyze Batch Operation, Semi continuous or Fed Batch Operation
CO4	Develop Enzyme and growth kinetic models
CO5	Understand Bioreactor Modelling
CO6	Develop models for biological systems

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	3	-		2	-	1	2	1	-	1	2	1	1
CO2	3	-	3	-	3	-	-	1	2	2	-	1	3	1	2
CO3	3	-	3	-		-	-	1	2	1	-	1	2	1	2
CO4	3	-	3	-		-	-	1	2	2	-	1	3	1	2
CO5	3	-	3	-	3	-	-	1	2	1	-	1	2	1	2
CO6	3	-	3	-	3	-	-	1	2	1	-	1	2	1	2

Detailed syllabus:

Modelling principles, use of models for understanding, design and optimization of bioreactors, simulation tools. Introduction and exploration of a few open ware software tools i.e Open modelica, XPP-Auto, COPASI, Virtual cell, MetNetMaker etc… for bio-systems modelling and simulation.

Formulation of balance equations, types of mass balance equations, balancing procedure, continuous stirred tank bioreactor, tubular reactor, river with eddy current, component balances for reacting systems, constant volume continuous stirred tank reactor, semi-continuous reactor with volume change, steady-state oxygen balancing in fermentation, inert gas balance to calculate flow rates, stoichiometry, elemental balancing and the yield coefficient concept.

Bioreactor modelling, biomass productivity, modelling of tubular plug flow bioreactors, gas absorption with bio reaction in the liquid phase, liquid-liquid extraction with bioreaction in one phase, steady- state gas balance for the biological uptake rate, determination of k_la using the sulfite oxidation reaction determination of k_la by a dynamic method, model for oxygen gradients in a bubble column bioreactor, model for a multiple impeller fermenter.

Simulation examples of biological reaction: Processes using berkeley madonna, batch fermentation(batferm), chemostat fermentation (chemo), fedbatch fermentation(fedbat), kinetics of enzyme action (mmkinet), repeated fed batch culture (repfed), lineweaver-burkplot (lineweav), steady-state chemostat(chemostat), variable volume fermentation (varvol and varvold), penicillin fermentation using elemental balancing (penferm),fluidized bed recycle reactor(fbr).Modelling and simulation of simple neuron using Hodgkin-Huxley equations.

Flow sheeting of the chemical process using Superpro Designer, Design of a Heat exchanger using Superpro Designer, Design of a Distillation column using Superpro Designer, Calculation of volume of a bioreactor using Superpro Designer, Design of pressure valves and compressors using Superpro Designer, Design of a evaporator using Superpro Designer, Design of a absorption column using Superpro Designer, Design of a extractor using Superpro Designer, Design of a dryer using Superpro Designer, Design of a filter using Superpro Designer, Design of wastewater treatment plant using Superpro Designer, Design of Bioreactors using Superpro Designer.

Readings:

1. J. Dunn, E. Heinzle, J. Ingham, J.E. Pfenosil “Biological Reaction Engineering: DynamicModellingFundamentalswithSimulationExamples”WILEY-VCHVerlagGmbH&Co.KGaA,Weinheitn, 2003
2. J.R.Leigh, Modeling and Control of fermentation Processes, Peter Peregrinus, London, 2000
3. SyamS.Sablanietal.Handbookoffoodandbioprocessmodellingtechniques,Taylor& FrancisGroup,LLC,2006

BT402	INSTRUMENTATION AND ANALYTICAL METHODS IN BIOTECHNOLOGY	PCC	3 – 0 – 0	3 Credits

Prerequisites: PH101 Physics, CH101 Chemistry, BT202-Biochemistry

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basics of bioanalysis and bioassays
CO2	Understand the principles and types of bioanalytical instruments.
CO3	Understand the spectroscopic techniques.
CO4	Compare and select appropriate chromatographic techniques
CO5	Analyze the mass spectrometrydata
CO6	Apply the bioanalytical techniques learnt in characterization of biomolecules.

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO2	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO3	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO4	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO5	3	-	-	2	3	-	-	2	-	-	-	-	3	-	-
CO6	3	-	-	2	3	-	-	2	-	-	-	-	3	3	-

Detailed Syllabus:
Introduction, Modern approaches in Bioanalysis and Bioassays

Microscopy Techniques- Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; SPM, AFM, Electron microscopy: TEM & SEM.Radioisotope techniques- Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science.

Spectroscopic techniques Spectroscopic techniques: UV-Visible spectroscopy, Fluorescence spectroscopy, IR spectroscopy, CD spectroscopy, NMR, X-ray, and Mass spectroscopy atomic absorption spectroscopy (AAS, inductively coupled plasma emission (ICP/AES), Fourier transform infrared spectrometry (FTIR), Infra-red spectroscopy – basic concepts, experimental methods, functional group analysis and identification using IR spectroscopy, structural effects on vibrational frequency

Advanced chromatographic techniques— gaschromatography (GC) with all the types of detectors—electron capture (ECD), flame ionization (FID), thermal couple (TCD), Nitrogen-Phosphorus (NPD) and mass spectrometry (MS), liquid chromatography with mass detection (LC-MS),high pressure thin layer chromatography (HPTLC), Mass Spectrometry – various ionization methods – EI, CI, ESI and MALDI methods, HRMS.

Reading:

1. Wilson K and Walker J "Principles and Techniques of Biochemistry and Molecular Biology" 6th Ed. Cambridge University Press, 2005.

2. Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Cengage Learning (Indian Edition), 2007.
3. Principles of Instrumental Analysis 6th Edition by Douglas A. Skoog (Author), F. James Holler (Author), Stanley R. Crouch (Author)

BT407	INSTRUMENTATION AND ANALYTICAL METHODS IN BIOTECHNOLOGY LAB	PCC	0 – 0 – 3	2 Credits

Prerequisites: BT202-Biochemistry.
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basics of bioanalysis and bioassays
CO2	Understand the principles and types of bioanalytical instruments.
CO3	Understand the spectroscopic techniques.
CO4	Compare and select appropriate chromatographic techniques
CO5	Analyze the mass spectrometry data
CO6	Apply the bioanalytical techniques learnt in characterization of biomolecules.

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO2	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO3	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO4	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO5	3	-	-	2	3	-	-	2	-	-	-	-	3		-
CO6	3	-	-	2	3	-	-	2	-	-	-	-	3	3	-

Detailed Syllabus:

1. Fluorescence microscopy
2. Gel shiftassay using radiolabeled probe
3. Fluorescence spectroscopy
4. IR spectroscopy
5. CD spectroscopy
6. AAS, inductively coupled plasma emission (ICP/AES),
7. Fourier transform infrared spectrometry (FTIR)
8. gaschromatography (GC)
9. HPLC
10. FPLC
11. SEM, XRD,NMR demonstration

Reading:

1. Wilson K and Walker J "Principles and Techniques of Biochemistry and Molecular Biology" 6th Ed. Cambridge University Press, 2005.
2. Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Cengage Learning (Indian Edition), 2007.
3. Principles of Instrumental Analysis 6th Edition by Douglas A. Skoog (Author), F. James Holler (Author), Stanley R. Crouch (Author)

BT441	SEMINAR	PCC	0 – 0 – 3	1 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Acquire knowledge on topics outside the scope of curriculum.
CO2	Communicate with group of people on different topics.
CO3	Collect and consolidate required information on a topic.
CO4	Prepare a seminar report.

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	3	3	-	-	-	-	3	-	-
CO2	-	-	-	-	-	-	-	-	2	3	-	-	3	3	-
CO3	-	-	-	-	-	-	-	3	-	-	-	-	3	-	-
CO4	-	-	-	-	-	-	3	3	1	3	-	-	3	-	-

Detailed Syllabus: Seminar topic (related to biotechnology or allied sciences)

Reading: Recent literature survey related to the seminar topic published in the peer reviewed National and International Journals

BT449	PROJECT WORK PART-A	PRC	0 – 0 – 3	2 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Carry out literature survey as a team and select a problem statement
CO2	Design experiments to execute project work.
CO3	Perform unit operation, bioprocess, statistical and genetic analysis.
CO4	Apply modern software tools for biological systems.

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	3	-	3	3	-	-	-	-	1	-	-	3	2	-
CO2	-	-	3	-	-	-	-	-	-	-	2	-	3	3	1
CO3	3	-	3	-	-	-	2	-	-	-	2	-	3	1	2
CO4	1	1	-	3	3	-	-	-	-	2	-	-	3	1	-

Detailed Syllabus: Project Topic

Reading: Recent literature survey related to the project topic published in the peer reviewed National and International Journals

BT451	BIOETHICS, BIOSAFETY AND IPR ISSUES	PCC	3 – 0 – 0	3 Credits

Prerequisites: BT101 Engineering Biology, BT203 Microbiology, BT252Molecular Biology & Genetics

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basic issues of biosafety, bioethics and IPR
CO2	Follow good laboratory procedures and practices
CO3	Justify the design of confinement facilities at different Biosafety levels
CO4	Understand the social and ethical issues related to plant, animal and modern biotechnology.
CO5	Review international agreements and protocols for Biosafety.

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
CO2	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
CO3	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3
CO4	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3
CO5	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3

Detailed Syllabus:

Introduction to Biosafety: Historical Background, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels, Biosafety Levels of Specific Microorganisms, Recommended Biosafety Levels for Infectious Agents and Infected Animals, Biosafety guidelines – Government of India.

Definition of GMOs & LMOs, Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture, Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication, Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Introduction to Intellectual Property, Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs, IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies.

Agreements and Treaties, History of GATT & TRIPS Agreement, Madrid Agreement; Hague Agreement, WIPO Treaties; Budapest Treaty; PCT, Indian Patent Act 1970 & recent amendments, Basics of Patents and Concept of Prior Art, Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition, Specifications: Provisional & complete; Forms & fees, Invention in context of “prior art”.

Patent databases: Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.), Patent filing procedures, National & PCT filing procedure; Time frame& cost; Status of patent applications filed, Precautions while patenting – disclosure/non-disclosure, Financial assistance for patenting - Introduction to existing schemes, Patent licensing and agreement, Patent infringement- meaning, scope, litigation, case studies

Bioethics: Necessity of bioethics, Origin and Evolution of ethics into bioethics, Ethical reasoning and the justification of moral beliefs, Different paradigms of bioethics - National and International

Reading:

1. Diane O. Fleming; Debra A. Long; Biological Safety: Principles and Practices, ASM Press; 4th edition, 2006
2. 2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information, 2007
3. Nancy Ann Silbergeld Jecker; Albert R. Jonsen; Robert A. Pearlman; Bioethics: Introduction to History, Methods, and Practice; Jones & Bartlett Publishers; II edition, 2007
4. Lim Li Ching; Terje Traavik; Biosafety First: Holistic Approaches to Risk and Uncertainty in Genetic Engineering and Genetically Modified Organisms; Tapir Academic Press, 2007
5. 21st Century Complete Guide to Biosafety and Biosecurity (CD-ROM): by U.S. Government, Publisher: Progressive Management, 2004
6. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., latest edition, 2007
7. Bonnie Steinbock; The Oxford Handbook of Bioethics (Oxford Handbooks): Oxford University Press, USA; 1st edition, 2007.

BT499	PROJECT WORK PART-B	PRC	0 – 0 – 6	4 Credits

Prerequisites: Nil

Course Outcomes: At the end of the course the student will be able to:

CO1	Demonstrate safe laboratory practices and handle the equipment safely to ensure personal, product and environmental safety
CO2	Design processes for sustainable energy and environment
CO3	Design process equipments and bioprocess plants.
CO4	Apply advanced bimolecular engineering tools to solve biomedical problems

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	3	-	3	3	-	-	-	-	1	-	-	3	2	-
CO2	-	-	3	-	-	-	-	-	-	-	2	-	3	3	1
CO3	3	-	3	-	-	-	2	-	-	-	2	-	3	1	2
CO4	1	1	-	3	3	-	-	-	-	2	-	-	3	1	-

Detailed Syllabus: Project Topic

Reading: Recent literature survey related to the project topic published in the peer reviewed National and International Journals

BT411	ANIMAL BIOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT204 Cell Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basics of animal cell culture
CO2	Apply aseptic techniques for cell culture
CO3	Design cell culture media for cell growth and product development
CO4	Characterize the animal cell using biochemical and molecular biology techniques
CO5	Apply the principles of genetic engineering to modify animal cell for research and industrial use.
CO6	Understand the concept of transgenic animal and animal breeding

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	3	-	-	2	-	-	1	-	-	3	-	-
CO2	-	3	-	3	2	-	2	-	-	-	-	-	3	-	-
CO3	-	-	-	2	2	2	3	-	-	-	-	-	3	-	1
CO4	1	2	-	3	2	-		-	-	-	-	-	3	-	
CO5	-	3	-	3	-	-	2	-	-	1	1	2	3	-	1
CO6	-	3	-	3	-	2		1	-	-	-	-	3	-	1

Detailed Syllabus:

Historical background, advantages and limitations Essential Equipments, General Safety Measures, Aseptic Techniques, Risk Assessment. Cryopreservation.

Media for culturing cells and tissues; natural and defined media, serum free and serum based media. Isolation of Cells and Tissues, primary and secondary cell cultures, development and maintenance of cell lines.

Characteristics of animal cells Morphological studies: Chromosome analysis, DNA content, RNA and Protein, Enzyme Activity, Antigenic Markers. Transformation: Immortalization, Aberrant Growth, Tumorigenicity. Transformation Assay, Cell counting, Cell Proliferation and Viability assay.

Recombinant Vaccine for animal health, Animal Breeds, Embryonic Stem Cell method, Transgenic Animal Production: Microinjection method, retroviral vector method, importance and applications of transgenic animals.

Reading:

1. Animal Cell Culture & Technology, 2nd Edition, Author: Michael Butler, Mike Butler, M. Butler
2. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications 6th Edition, Author: R. Ian Freshney, Freshney

BT412	MEDICAL BIOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT202 Biochemistry, BT203 Microbiology

Course Outcomes: At the end of the course the student will be able to:

CO1	Study the clinical applications of gene and cellular therapy
CO2	Understand the concept of tissue engineering
CO3	Understand and analyze the clinical applications of recombinant technology
CO4	Understand the theory of gene silencing and antisense therapy
CO5	Study the principles of immunotherapy and vaccine development
CO6	Study the principles and applications of transgenics

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1	3	-	-	-	-	-	-	3	-	-
CO2	2	3	-	2	-	3	-	-	-	-	-	-	3	-	-
CO3	-	-	3	3	1	3	-	3	-	-	-	-	3	2	2
CO4	2	2	3	3	-	3	-		-	-	-	-	3	2	-
CO5	1	3	2	3	-	3	1	3	-	1	-	2	3	3	2
CO6	-	-	-	3	-	3	2	3	-	1	-	1	3	2	3

Detailed Syllabus:

History of Gene therapy, Types of Gene therapy: In vivo & Ex vivo; Somatic & Germline Gene therapy, Introduction to Suicide Gene therapy: Suicide genes; bystander effect, Vectors for Gene therapy: viral & non-viral, Introduction to cellular therapy, Methodologies involved in cellular therapy, Clinical applications of cellular therapy.

Stem cells: Introduction, types, Therapeutic applications of stem cell therapy, Concept of Tissue engineering, Clinical applications of Tissue engineering.

Introduction to Recombinant therapy, Techniques involved in Recombinant therapy, Clinical applications of recombinant technology, Preface to Immunotherapy, Examples and applications of immunotherapy.

Concept of Gene silencing, Gene silencing techniques, Clinical applications of Gene silencing, Method of Antisense therapy, Clinical applications of Antisense therapy.

Vaccines: Types of Vaccines, Clinical applications of Recombinant vaccines, Introduction to Transgenics, Clinical and therapeutic applications of Transgenics.

Reading:

1. Pamela Greenwell, Michelle McCulley, Molecular Therapeutics, 21st Century Medicine, John Wiley & Sons Ltd, 2007.
2. Judit Pongracz, Mary Keen, Medical Biotechnology, Churchill Livingstone, Elsevier, 1st Edition, 2009.
3. 3. Bernhard O. Palsson, Sangeeta N. Bhatia, Tissue Engineering, 2nd Edition, Prentice Hall, 2004.

BT413	BIOPHARMACEUTICAL TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: BT202 Biochemistry, BT203 Microbiology, BT204 Cell Biology.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the different forms of drugs with its therapeutic applications
CO2	Identify various routes of drug administration
CO3	Classify the metabolism of various drug types in the human body
CO4	Employ recombinant DNA technology for the manufacturing various pharmaceutical products
CO5	Apply the good manufacturing practices for the production of pharmaceutical products

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	1	-	3	2	1	-	-	-	3	3	2	3
CO2	3	3	3	2	3	1	-	1	-	-	-	1	3	1	2
CO3	2	3	3	3	2	2	2	1	-	-	-	1	3	-	2
CO4	3	3	3	3	2	2	2	2	2	2	1	3	3	3	2
CO5	3	3	3	3	3	1	2	1	3	2	2	3	3	3	3

Detailed Syllabus:

History and definition of drugs, Sources of drugs: plants, animals, microbes and minerals, concepts of drug dosage of solid, semi-solid, liquid, aerosol, tablets and capsules, routes of drug administration, controlled and sustained drug delivery of drug, Biomaterials for drug delivery, liposome mediated drug delivery.

Pharmacodynamics and pharmacokinetics of drugs, Absorption, Distribution of drugs, Biotransformation and bioavailability of drugs, Dose-response relationships, mechanism of action of drug, theory of drug-receptor, compartment modeling, half-life of drug, Apparent volume, Renal-Plasma clearance, Total-body clearance.

Biopharmaceutical products and their importance, manufacture of tablets, compressed tablets wet and dry granulation, ; slugging or direct compression direct compression, coating of pills, capsules, parental solution, oral liquids, ointment, Laxatives, Analgesics, non-steroidal contraceptives, analytical and testing methods used in drug manufacture, packing techniques; quality management; Good manufacturing practices.

Monoclonal antibodies, production of monoclonal antibodies, Biological Hormones: insulin, glucagon, human growth hormone, gonadotrophins, human growth hormone, Cytokines, Interferons, Tumor Necrosis Factor (TNF), transgenic animals and plants, recombinant DNA technology and its application in biopharmaceutical industry.

Reading:

1. G. Walsh, Biopharmaceuticals Biochemistry and Biotechnology, 2nd Edn., John Wiley 2002.
2. L. S. Goodman, J. G. Hardman, L. E. Limbird, and A. G. Gilman, Goodman & Gilman's the Pharmacological Basis of Therapeutics, 10th Edn., McGraw-Hill, 2001.
3. S. B. Primrose, R. M. Twyman, and R. W. Old, Principles of Gene Manipulation, 6th Edn., Wiley Blackwell, 2001.

BT421	NANOBIOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Prerequisites: Nil

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basic principles of nanotechnology
CO2	Study physical, chemical and biological methods for synthesis of nano materials
CO3	Apply the concepts of nanotechnology for biosensors
CO4	Apply the concepts of nanotechnology for drug delivery and gene therapy.

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	-	2	-	2	-	-	-	-	-	-	3	1	-
CO2	1	2	-	2	2	1	-	-	-	-	-	-	3	-	-
CO3	2	1	1	2	2	-	-	-	1	-	-	-	3	-	-
CO4	3	1	-	1	1	-	1	-	-	-	-	-	-	-	-

Detailed Syllabus:

Introduction to Nanotechnology and Nano-biotechnology, Types of nanomaterials: Nanoparticles, Nanowires, Nanotubes, Thin films and Multilayers, Properties of Nanomaterials, Biomolecules as Nanostructures, Molecular Motors.

Methods of preparation of nanomaterials, Nanoparticle synthesis using microbes, Basic characterization techniques: Electron microscopy, Atomic force microscopy, Photon correlation spectroscopy. Functionalization of nanomaterials for biological applications.

Applications of nanomaterials in optical biosensors and imaging, quantum dots, Nanomaterials in electrochemical biosensors, Nanomaterials in bioseparation.

Nanostructures for drug delivery, Nanovesicles; Nanospheres; Nanocapsules, Magneticnanoparticles; Liposomes; Dendrimers, Concepts, Targeting, Routes of delivery andadvantages, Drug-Photodynamic therapy, gene therapy. Recent trends in nanobiotechnology.

Reading:

1. M.Ratner and D.Ratner,Nanotechnology –a gentle introduction to the next big idea, Pearson education , Latest edition.2007.
2. Nanobiotechnology: Concepts, Applications and Perspectives *by Christof M. Niemeyer, Chad A. Mirkin.*Wiley, John & Sons*.2004. 1st Edition.*
3. L.E.Foster, Nanotechnology-Science, Innovation and opportunity, Person education inc, Latest edition. 2007

BT422	BIOMATERIALS TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT202 Biochemistry, BT203 Microbiology; BT204 Cell Biology

Course Outcomes: At the end of the course the student will be able to:

CO1	Classify and understand the properties of biomaterials
CO2	Understand the concept of biocompatibility
CO3	Assess biocompatibility of materials using in vivo and in vitro techniques
CO4	Understand the concepts for developing new materials for tissue engineering and bio-implant applications
CO5	Understand the applications of Biomaterials
CO6	Forecast the entrepreneurship opportunities in in Biomedical device industry

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	2	-	-	-	-	-	-	-	-	-	3	2	2
CO2	3	1	-	3	-	-	-	-	-	-	-	-	3	2	2
CO3	2	2	3	3	-	-	-	-	-	2	-	-	3	2	3
CO4	2	3	3	2	-	2	2	-	-	2	-	-	3	3	3
CO5	2	3	3	-	2	2	2	-	-	2	-	-	3	3	3
CO6	2	-	-	-	-	-	-	-	-	3	-	-	3	3	2

Detailed Syllabus:

Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials. Classes of materials in medicine.

Concept of biocompatibility; Structure and properties of biological cells & tissues; cell material interactions and host reaction to biomaterials and evaluation; Assessment of biocompatibility of biomaterials, *in vitro* biochemical assays (cellular adhesion, cellular viability using MTT osteogenic differentiation using ALP assay; Biomnuneralisation using Osteocalcin assay)

Degradation of Materials in Biological environment: Biodegradation of Biodegradable Polymeric Biomaterials, Degradative Effects of the Biological Environment on Metals andCeramics, Pathological Calcification of Biomaterials

Applications of Biomaterials: Nonthrombogenlc Materials and Strategies: Case Study, Cardiovascular Medical Devices, Dental implantation, ophthalmic applications.

Applications of Biomaterials in Functional Tissue Engineering, Bone Tissue Engineering, Cartilage and ligament Tissue Engineering, Blood Vessel Tissue Engineering, Heart Valve Tissue Engineering

Design concept of developing new materials for bio-implant applications. Ethical and legal Issues in Biomaterials and Medical Devices. Entrepreneurship in Biomaterials.

Reading:

1. Buddy D. Ratner, *Biomaterials Science*: An Introduction to Materials in Medicine 3rd Edition, Academic Press, 2014
2. Sujatha V. Bhat, Biomaterials, 2nd Edition , Narosa Publishing house,2010
3. Fredrick H. Silver Medical Devices and Tissue engineering: An integrated approach 1st edition , chapman and Hall Publications,1993
4. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.
5. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.
6. Basic Cell Culture: A Practical Approach, Edited by J.M. Davis, IRL Press, Oxford University Pres, New York, 1994.
7. Comprehensive structural interity, Vol.9: Bioengineering Editors: Mithe, Ritchie and Karihalo, Elsevier Academic Press, 2003.

BT423	STEM CELL AND TISSUE ENGINEERING	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT204 Cell Biology, BT303 Immunology

Course Outcomes: At the end of the course the student will be able to:

CO1	Classify stem cells
CO2	Understand the construction of connective tissues
CO3	Understand the process of isolation and identification of stem cells
CO4	Understand the construction of biomaterials
CO5	Review the human stem cell research in India

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	2	-	-	-	-	-	1	-	-	-	-	-
CO2	2	-	-	3	-	2	-	3	-	-	-	-	2	-	-
CO3	-	3	-	2	-	-	-	-	2	-	2	-	-	1	-
CO4	-	2	3	3	2	-	1	-	-	1	-	1	-	-	2
CO5	-	3	-	3	-	1	2	-	-	2	-	-	-	-	1

Detailed Syllabus:

Cell types and sources and stem cells, Cell culture media, Culturing of cell lines-monolayer and suspension types of cultures, Biology and characterization of cultured cells, Maintenance and management of cell lines. Embryonic and adult stem cells, Cell isolation and selection; cell preservation.

Extracellular matrices; Cell-matrix interactions. Cell synthetics surface interactions and the ensuing effects on cell growth, cell adhesion, cell migration, and cell-cell communication. Cell and Tissue Culture, Cell characterization, cell separations, Mechanical properties of biological tissues.

Cell-Biomaterial Interactions and Host Integration. Biomaterial processing for Tissue Engineering. Natural and Synthetic Scaffolds for Tissue Engineering.

Bioreactor for tissue engineering – Introduction, Design and scale up, Hollow fibre systems, Micro carrier based systems.

Differentiation of Astocytes and Oligodentrocytes, stem cells and cloning. Artificial skin. Artificial blood vessels, Bone repair, Repair of cartilage, tendon and ligaments.

Immunolabelling procedures, stem cells and cloning. Type of stem cell transplantation – Autologous, Allogeneic, Syngeneic, Nuclear transplantation, Transfection methods – Lipofection, Electroporation, Microinjection, Human stem cell research in India, Human embryonic stem cell ethics and Public policy.

Reading:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition, R. Ian Freshney, 2011
2. Stem Cell Biology, David Gottlieb, Cold Spring Harbor, 2002
3. Essentials of Stem Cell Biology 3rd Edition, Robert Lanza Anthony Atala,2013
4. Principles of Tissue Engineering, Robert Lanza, Robert Langer and Joseph Vacanti, Elsevuer, 2013
5. Tissue Engineering, Academic Press, by Clemens van Blitterswijk, 2008

BT461	PROTEIN ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: BT202 Biochemistry

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply suitable methods to screen desired engineered proteins
CO2	Understand importance of scaffolds for protein engineering
CO3	Design new scaffold for protein engineering
CO4	Use different non-canonical amino acids for protein engineering
CO5	Apply appropriate mutagenesis methods for protein engineering

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	-	2	2	1	-	-	-	-	-	3	3	2	-
CO2	3	2	-	1		2	1	-	-	-	-	2	3		1
CO3	3	3	3	3	3	2	2	1	-	-	-	3	3	3	2
CO4	3	3	2	3	3	1	-	-	-	-	-	3	3	2	-
CO5	3	3	2	3	3	2	-	-	-	-	-	3	3	2	3

Detailed Syllabus:

Library construction for protein engineering, Screening methods for epitope recognition (Phage Display, Cell Surface Display and Cell Free Display Systems), Vectors and platforms, Advantages and limitations.

Non-antibody scaffolds for design and engineering of synthetic binding proteins, various scaffolds (β-sandwitch, β-barrel, β-sheet, α-helical scaffolds, Single loop, Multidomain Scaffold), Designing of new scaffolds.

Different methods for protein engineering using non-canonical amino acids, Side chain packing, Novel folds and control of orientation, Backbone mutation, Using fluorescent amino acids, Engineering of therapeutic proteins, Source, target and mode of action of protein therapeutics, Designing effective protein therapeutics with examples.

In-vitro mutagenesis: Principles and variations, Strategies for mutagenesis (Chemical, Oligonucleotide directed, Cassette mutagenesis, PCR mutagenesis) and their limitations, Mutagenesis on non-coding DNAs, Mapping of functional domains of proteins.

References:

1. Protein Engineering and Design by Sheldon J. Park and Jennifer R. Cochran, CRC Press, 2010.
2. Protein Engineering and Design by Paul R. Carey, Academic Press, 1996.

BT462	METABOLIC REGULATION AND ENGINEERING	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT202 Biochemistry, BT203 Microbiology

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the overview of cellular metabolism and connection between metabolic pathways.
CO2	Understand the metabolic pathway regulation at transcription and translation level.
CO3	Differentiate regulatory mechanisms involved in biosynthesis of primary and secondary metabolites
CO4	Apply the concept of auxotrophic mutations for the synthesis of primary and secondary metabolites
CO5	Understand the concept of bioconversions and its applications
CO6	Understand the concepts for developing heterologous pathways for production of value added compounds
CO7	Understand and apply the Modeling Tools for Metabolic Engineering

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	-	2	-	-	-	-	-	-	-	-	3	2	2
CO2	2	3	-	3	1	-	-	-	-	-	-	-	3	2	2
CO3	3	-	-	3	-	2	-	-	-	-	-	-	3	2	2
CO4	3	-	-	3	-	2		-	-	-	-	-	3	3	3
CO5	2	-	-	3	-	1	2	-	-	-	-	-	3	3	3
CO6	-	2	3	2	-	-	-	-	1	-	-	-	3	3	3
CO7	2	2	-	2	-	-	-	3	-	3	-	-	3	3	3

Detailed Syllabus:

Basic concepts of Metabolic Engineering – Overview of cellular metabolism – Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation.

Synthesis of primary metabolites: Amino acid synthesis pathways and its regulation at enzyme level and whole cell level, Alteration of feedback regulation, Limiting accumulation of end products.

Biosynthesis of secondary metabolites: Regulation of secondary metabolite pathways, precursor effects, prophase, idiophase relationship, Catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites, applications of secondary metabolites.

Regulation of enzyme production: Strain selection, Genetic improvement of strains, Gene dosage, metabolic pathway manipulations to improve fermentation, Feedback repression, Catabolite Repression, optimization and control of metabolic activities.

Pathway manipulations: The modification of existing - or the introduction of entirely new - metabolic pathways. Modeling Tools for Metabolic Engineering: Metabolic Flux and Control Analysis, Modelling of metabolic networks

Reading:

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998
2. Daniel I. C. Wang, Malcolm D. Lilly, Arthur E. Humphrey, Peter Dunnill, Arnold I.Demain, Fermentation and Enzyme Technology,1st edition John Wiley& Sons, Reprint, 2005
3. Christina Smolke, The Metabolic Pathway Engineering Handbook (Two Volume) Set 1st edition CRC press, 2009.

BT463	SYSTEMS BIOLOGY	DEC	3-0-0	3 Credits

Prerequisites: BT251-Molecular Biology and Genetics, BT252- Cell Biology, MA251- Mathematics IV, MA201 – Mathematics - III, BT 351 Bioreaction Engineering

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand basic, advanced principles of systems biology and biological networks
CO2	Understand networks behaviour and emergent properties of biological networks/ systems
CO3	Understand why systems level studies are essential in biology through case study based examples
CO4	Apply kinetics principles to develop systems level mathematical models in biology
CO5	Draw insights form such systems level models and studies for biotechnological and biomedical applications.

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	3	-	1	-	1	-	-	-	-	3	1	-
CO2	3	3	3	3	-	-	-	2	-	-	-	-	3	-	2
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	-	2
CO4	3	3	3	3	3		-	-	-	-	-	-	3	-	2
CO5	3	2	3	2	3	1	-	-	-	-	1	1	3	1	2

Detailed Syllabus:

Systems biology-fundamentals: Introduction to systems biology; high throughput experimental techniques: gene array, protein array, two-hybrid systems; model formulation based on enzyme kinetics, Michaelis-Menten kinetics, mass actions kinetics, Hill equation, steepness, threshold phenomenon, ultrasensitivity, steady state, dynamic and stochastic models in system biology.

Molecular networks and cellular behavior: Emergent properties of biological networks; complexity, adaptability, bistability, robustness and evolvability; introduction to network motifs, elements of transcription networks, dynamics and response time of simple gene regulation, autoregulation, feed forward loops (FFLs), temporal expression programs and global structure

Case studies, computations tools and applications : Signal transduction networks, *E. coli* chemotaxis network, infection model, robustness patterning in development- morphogen profiles, fruit fly patterning, threshold and negative feedback loop in rhythmic processes (oscillations) of complex biological system, Computational tools and software packages, Synthetic biology: building and analyzing synthetic networks, systems pharmacology.

Reading:

1. Introduction to Systems Biology. URI ALON. Chapman and Hall/CRC Mathematical and Computational Biology, 2007.
2. Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Edited By ZOLTAN SZALLASI, JÖRG STELLING, VIPUL PERIWAL. Princeton Hall of India. ISBN: 978-81-203-3172-3, 2007.
3. Eberhard O. Voit, Computational Analysis of Biochemical Systems, Cambridge University Press, 2000.

BT471	FOOD BIOTECHNOLOGY	DEC	3-0-0	3 Credits

Prerequisites: BT202 Biochemistry, BT203 Microbiology

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the components and nutritional value of food
CO2	Understand nutraceuticals and their impact on health
CO3	Identify microbes that preserve and spoil food
CO4	Understand various fermentation processes in food industry
CO5	Understand industrial production processes and quality measures practiced

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	3	-	-	-	3	2	1	1	1	2	3	3	-	2
CO2	-	3	-	-	-	3	2	1	1	1	2	3	3	-	2
CO3	2	2	3	3	3	3	3	1	1	1	2	3	3	3	
CO4	2	2	3	3	3	2	2	1	1	1	1	3	3	3	2
CO5	3	3	2	3	2	3	1	1	1	2	1	3	3	3	2

Detailed Syllabus:

Introduction to food biotechnology, components of food: carbohydrates, proteins, Fats, Nutrition: Balanced diet, Essential amino acids and fatty acids, vitamins, minerals, Anti-nutrients, Nutrition deficiency diseases.

Nutraceuticals, Nutraceuticals Vs Pharmaceuticals, Prebiotics, probiotics, micronutrients, nuts and grains, Phyto-nutraceuticals, bio-fortification, life style disorders and personalized nutrition.

Microorganisms in food processing and their characteristics, sources, use of enzymes in food industry, Sources, production of single cell protein and application in food industry. Genetically modified food. Fermented food, Industrial production and preservation of fermented foods: Dairy products, cheeses, yogurt and acidophilus milk. Edible mushrooms and their cultivation, Beverages – non - alcoholic (sauerkraut, Idly, Peanut milk and fermented soya).

Food spoilage, Bacterial agents of food borne illness -*Clostridium, Vibrio, Salmonella*. Non-bacterial agents of food borne illness – protozoa, Algae, fungi, viruses. Food preservation, Role of chemicals in food preservation. Meat and fish preservation.

Product development, Processing techniques, Toxicology studies, clinical trials associate with product development. Food additives, food sweeteners and colours, Quality materials used in food processing (e.g.: Organic acid, cellulose and cellulose derivatives. Food quality maintained by EFSA (European food safety authority) and FDA (Food and Drug Authority).

Reading:

1. B.H. Lee, Fundamentals of Food Biotechnology, 1st edition ,John Wiley & sons Ltd. 2015
2. J. M. Jay, M. J. Loessner, and D. A. Golden, Modern Food Microbiology, 7^{th}Edition, Springer, 2006.
3. P. J. Green, Introduction to Food Biotechnology, 1st Edition, CRC, 2002.
4. K. Shetty, G. Paliyath, A. Pometto, and R. E. Levin, Food Biotechnology, 2^{nd}Edition., CRC, 2005.

BT472	MACHINE LEARNING TECHNIQUES	DEC	3-0-0	3 Credits

Prerequisites: BT452-Biostatistics, BT202-Biochemistry, BT251-Molecular Biology and Genetics, CS101-Problem Solving and Computer Programming, MA101-Mathametics-I.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand The Application of Mathematics For Biological Data.
CO2	Understand The Role of Statistics In Molecular Biology Data.
CO3	Learn The Concepts of Bayesian Networks That Can Be Applied To Solve The Biological Problems
CO4	Broad Overview of The HMMs, SVMs, Neural Networks and Their Applications
CO5	They Will Be Able Apply These Technics To Derive Significant Insights of Biological Data.

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO2	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO3	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO4	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO5	3	-	-	2	3	-	-	2	-	-	-	-	3	-	-

Detailed Syllabus:

Introduction to Markov chains and HMMs, discrete HMMs: quantized Lorenz time series, hidden states as parts of speech. Algorithms for HMMs: Forward, Back ward, vieterbi, Baum-wulch, EM-ALGORITHM. Applications of HMM in gene identification and Profiles HMMs, applications of proteins, DNA, RNA.

Introduction to Genetic algorithms, GA operators: population, reproduction, chromosome, cross over, recombination, mutation. Classification of genetic algorithms: introduction, simple genetic algorithm (SGA), Parallel and Distributed genetic algorithm (PGA and DGA), Hybrid genetic algorithm (HGA), Adaptive genetic algorithm (AGA)

Introduction to neural networks, differences between artificial neuron and natural neuron. Hebbs rule, concept of perception, firing rules, architecture and topology of the Neural networks, the learning process in NNs, transfer functions in neural network. Back-propagation algorithm, Neural Networks Applied to Secondary Structure Prediction, NN applications in bioinformatics. Software examples for classification Methods.

Introduction to SVMs, linear and nonlinear classifiers, regression, function of hyper plane, kernel trick functions, confusion matrix for the biological problem and biological applications of svms.

Reading:

1. Hidden Markov models and dynamical systems By Andrew M. Fraser
2. Bioinformatics: The Machine Learning Approach, Pierre Baldi and Søren Brunak- The MIT Press
3. Introduction to genetic algorithms By S. N. Sivanandam, S. N. Deepa. Spinger-verlag
4. Evens, W.J. and Grant, G.R., Statistical Methods in Bioinformatics: An Introduction.
5. Jae K. Lee, Statistical Bioinformatics, John Wiley & Sons Inc.
6. Bioinformatics Sequence analysis: David Mount.
7. Foundations of Genetic programming William. B.Langdon, richardo Poli. Springer
8. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
9. Daniel Wayne W., Biostatistics: A Foundation for Analysis in the Health Sciences, 9th Ed., John Wiley & Sons, 2008.

BT473	ENZYME TECHNOLOGY	DEC	3-0-0	3 Credits

Prerequisites: BT202-Biochemistry, BT203 Microbiology BT302-Biological reaction Engineering

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand basics and principles of Enzyme Technology
CO2	Understand concepts in enzyme kinetics and enzyme inhibitors
CO3	Understand the immobilization techniques and their industrial applications
CO4	Learn methods for isolation, purification of enzymes of commercial importance
CO5	Apply principles of enzyme technology in order to develop an efficient enzymatic process

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	1	-	-	-	-	-	-	-	-	2	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO3	1	-	-	1	1	-	-	-	-	-	-	-	-	2	-
CO4	-	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO5	1	-	2	3	-	-	-	-	-	-	-	-	-	3	2

Detailed Syllabus:
General introduction, Nomenclature and Classification of enzymes, Biological Roles, Activation energy, Coenzymes, Cofactors, Prosthetic group, Metalloenzymes, Enzyme activity, Specificity and Selectivity,Identification of binding and catalytic sites, Enzyme reactions.

Enzyme-substrate interaction: Lock and Key mechanism, Induced Fit mechanism and Transition state Hypotheses, Factors affecting the enzyme action- Concentration, temperature and pH, Enzyme Kinetics: Michaelis-Menten Equation, Measurement of Km and Vmax, different plots for enzyme kinetics, Kinetics of multisubstrate reaction: Sequential reactions and ping-pong reactions. Multienzyme complex and multifunctional enzymes, Enzyme inhibition: Rreversible (competitive, uncompetitive and mixed) and irreversible, Allosteric regulation of enzyme activity,

Use of enzymes in free solution and associated problems; stabilization of soluble enzymes; objectives of enzyme immobilization, Principles & techniques of immobilization, Immobilized enzyme reactions; Analysis of mass transfer effects on kinetics of immobilized enzyme reactions, Analysis of film and Pore diffusion effects on kinetics of immobilized enzyme reactions, Calculation of effectiveness factors of immobilized enzyme systems, Design of enzyme electrodes

Sources of industrial enzymes (natural & recombinant), Strategies of isolation and purification of new enzymes from different sources, Large-scale industrial enzyme production, downstream processing, Modification of enzymes: Methods in enzyme engineering, Site directed mutagenesis;

Applications of enzymes for industrial processes and manufacture of commercial products, Industrial Enzymes: Proteases, Lipases, Carbohydrate active enzymes, Nucleic acid enzymes, artificial enzymes, Applications of enzymes in food industry, detergents, energy, waste treatment, pharmaceutical, medical and analytical purpose.

Reading:

1. Palmer, T., Bonner, P., “Enzymes Biochemistry, Biotechnology, Clinical chemistry”, 2nd edition, WoodHead Publishing, 2008.
2. Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer, Biocatalysts and Enzyme Technology, 2nd Edition, Wiley Publishing, 2012
3. Copeland, R. A., “Enzymes- A Practical Introduction to Structure, Mechanism and data analyses” 2nd Edition, WILEY–VCH, 2012

BT481	NEUROBIOLOGY	DEC	3-0-0	3 Credits

Prerequisites: BT204 Cell Biology

CO1	Understanding on neuronal architecture
CO2	Underlying molecular mechanisms communication
CO3	Understanding the neurons characterizations and differentiation
CO4	Understanding the effect of pharmaceuticals on neurons
CO5	Understanding the diseases of nervous system

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO3	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO4	3	2	-	1	-	-	-	-	-	-	-	-	3	1	2
CO5	2	--	-	1	-	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:

Unit I: Introduction to Nervous Systems, Central and Peripheral nervous systems

Unit II: Neuro Anatomy I, Structure and functions of neurons, synapse. Their function, signals produced byneurons, sensors function, Glial cells.

Unit III: Neuro Anatomy II Molecular and cellular organization of neuronal differentiation, characterization of neuronal cells.

Unit IV: Neurophysiology Conduction of impulses by neurons, Correlation of sensory functions.

Unit V: Neuropharmacology Pharmaceutical mediator, released by neurons. Hormones and their effect on neuronal function.

Unit VI: Neurological Disorders Pathogenesis, Genetic basis of neurological disorders

Reading:

1. Gordon M. Shepherd, Neuro Biology, Third Edition, Oxford University Press, USA
2. Mathews G.G. Neurobiology, 2nd Edition, Blackwell Science, UK
3. Mason P., Medical Neurobiology, Oxford University Press.

BT482	Omics Technologies	DEC	3 – 0 – 0	3 Credits

Prerequisites:BT253-Molecular biology& Genetics

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the advanced and complex landscape of today's cutting edge research in biology
CO2	Understand the basic principles and techniques of OMICS (transcriptomics, proteomics, metabolomics)
CO3	Understanding the principles, methods of data integration from different OMICS techniques.

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	-	1	-	-	-	-	-	-	3	1	1
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	-	-

Detailed Syllabus:

Genomics : Introduction to genome structure, DNA microarray, whole genome sequencing, Concept of next generation sequencing technology, Large scale genome sequencing strategies, Transcriptomics (RNA sequencing) & analysis of transcriptomic data, Concepts and principles of genome annotation, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs; statistical analysis genomic data.

Proteomics : Mass spectrometry – ionization methods (MALDI, electrospray), mass analysers, fragmentation, intact protein analysis, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, Introduction to quantitative proteomics- Differential proteomics, post-translational modifications. Computational methods for identification of polypeptides from mass spectrometry Protein arrays: basic principles, bioinformatics-based tools for analysis of proteomics data. Analysis of transcriptomic and proteomic data. Protein-protein interaction.

Metabolomics: Metabolomics-an overview, Analytical techniques for metabolomics; Mass spectrometry in metabolomics. Targeted Vs Untargeted metabolomics; development of targeted assays for small molecules; Metabolic pathway analysis; Metabolomics data analysis – case studies- workflow for lipidomics.

OMICS and Big Data management: Big data industry standards, Data acquisition, cleaning, distribution, and best practices, Visualization and design principles of big data, Biological databases for big data management, High Performance Computing, grid, and cloud computing for omics sciences.

Reading:

1. Principles of Genome Analysis and Genomics (3rd Ed.) by Primrose, S.B. and Twyman, R.M., Blackwell Publishing Company, Oxford, UK. 2003
2. Introduction to Proteomics – Tools for the new biology (1st Ed.) by Liebler, D.C., Humana Press Inc., New Jersey, USA. 2002
3. Bioinformatics and Functional Genomics by Pevsner, J., John Wiley and Sons, New Jersey, USA. 2003
4. Bioinformatics: Sequence and Genome Analysis by Mount, D., Cold Spring Harbor Laboratory Press, New York. 2004

BT483	Oncology	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT 253Molecular biology, & Genetics
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand characteristic features of tumor cells.
CO2	Understand factors that contribute to cancer development
CO3	Understand various genetic and molecular changes normal cells undergo during transformation into malignant cancer cells
CO4	Know cancer prevention and currently available therapeutic treatments

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	2	3	-	-	2	-	-	1	-	1	3	-	-
CO2	-	-	2	3	-	-	-	-	-	-	-	1	3	-	-
CO3	-	-	3	2	-	2	-	-	-	-	-	1	3	-	1
CO4	1	-	3	3	-	-	3	-	-	-	-	1	3	-	1

Detailed Syllabus:

Introduction to cancers, classification and characterization of cancers, causes of cancer, properties of cancer cells, principles of therapies, targets of therapies;Tumor genetics: mutations, carcinogenic agents, inheritance, tumor genes, defects in DNA repair and predispositions to cancer; Tumor epigenetics: mechanisms of epigenetic inheritance, imprinting, DNA methylation, epigenetics of cell differentiation and tissue homeostasis.

Oncogenes and tumor-suppressor genes; The cell cycle, apoptosis and senescence: checkpoints, therapeutic targets and inhibitors, molecular mechanisms of apoptosis, replicative senescence and its disturbances in human cancers; Signaling pathways in tumors: MAPK, PI3K, TP53 network, NFκB, TGFβ, STAT signaling.

Invasion and metastasis: genes and proteins involved in cell-to-cell, cell-matrix adhesion, in extracellular matrix remodeling during tumor invasion; angiogenesis.The role of immune system in tumors: inflammation, infections, cancer vaccines, inhibition of the immune system; Stem cells and cancer: Wnt signaling, Hh signaling.

Cancer prevention: nutrients, energy metabolism of tumors, hormones and gene interactions; Diagnosis of tumors: molecular diagnosis, molecular detection and classification;Cancer therapy: cancer chemotherapy, targeted drug therapy, immunotherapy, gene therapy.

Reading:

1. Robin Hesketh. Introduction to Cancer Biology Cambridge, University Press 2013.
2. 2Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics (2nd Edition) by Lauren Pecorino. Oxford University Press.
3. Molecular Biology of the Cell, by Bruce Alberts , Alexander D. Johnson , Julian Lewis

BT491	ENTREPRENEURSHIP IN BIOTECHNOLOGY	DEC	3-0-0	3 Credits

Prerequisites: SM35 Engineering Economics & Accountancy
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the scope, importance of biotechnology and allied fields.
CO2	Role of entrepreneurship in economic development of industry.
CO3	Learnt to do Market survey and assessment
CO4	Preparation of Business Plan; learn Forms of business organization/ownership.
CO5	Case study of any top three Biotechnology Companies (start up, various stages in establishment, .etc.,)

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	-	-	-	-	1	1	-	1	2	-
CO2	-	-	2	2	1	1	2	1	2	2	3	1	-	1	1
CO3	-	1	-	-	-	-	1	-	1	1	1	3	-	1	-
CO4	-	-	2	2	1	-	1	2	1	2	1	1	-	2	1
CO5	1	1	2	1	2	1	2	-	1	1	2	1	1	1	2

Detailed syllabus:

Introduction to Biotechnology & Applications: Biotechnology – definition, history, thrust areas of biotechnology; Elements of Bio-Process Engineering; Biotech Industries; Basic concepts of GLP, GMP and FDA; Scope and Importance of Biotechnology and allied fields.

Introduction to Bio-entrepreneurship: Definition of Bioentrepreneurship, traits of an entrepreneur; Copyright, Patents, trademark, plant breeders and farmers' rights, biodiversity related issues; Biopiracy, International and Indian business policies with the focus on Bio and Pharmaceutical products.

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Planning a Small Scale Enterprsies: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site. Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership. Case study of any top three Biotechnology Companies (startup, various stages in establishment, .etc.,)

Reading:

1. G.G. Meredith, R.E.Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
2. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
3. Patzelt, Holger, Brenner, Thomas (Eds.). Handbook of Bioentrepreneurship. Springer, 2008.
4. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
5. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.
6. Lee, James W., 2013. Advanced Biofuels and Bioproducts. Springer New York,
7. C. T. Hou, Jei-Fu Shaw, 2008. Biocatalysis and Bioenergy Wiley

BT492	DRUG DESIGN & DEVELOPMENT	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT 353 Bioinformatics &Computational Biology.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the concept of structure-function relationship of lead molecules in drug discovery
CO2	Understand the target identification in drug discovery
CO3	Apply proteomics and genomics techniques in drug discovery and design process
CO4	Understand drug delivery systems
CO5	Design new drugs using computational methods

Mapping of the Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	2	2	2	-	-	1	1	-	1	3	2	-
CO2	-	3	3	3	3	1	-	-	1	-	1	-	3	2	-
CO3	-	2	2	3	3	2	-	-	1	1	-	-	3	-	2
CO4	-	1	3	3	3	2	-	-	1	1	1	1	3	-	2
CO5	-	2	3	3	3	3	2	-	1	1	-	1	3	-	3

Detailed Syllabus:

Economic importance of drug discovery, Stages of drug discovery, Phases in drug discovery, identification, validation and diversity of drug targets, Structure and function of different targets enzymes, ion channels and receptors. Molecular recognition in Ligand - Protein Binding. Structure – Based and Ligand – Based Drug Design. Functional selectivity of receptors.

Stereochemistry in Drug Design, Peptides and Peptidomimetics. Bonded and non - bonded interactions, Drug delivery systems for proteins and peptides with special reference to oral & nasal routes. Delivery consideration of Biotechnological products: Stability profile, Barriers to peptides and protein delivery, Delivery of protein and peptide drugs, Site specific protein modification, Toxicity profile characterization.

High-Throughput Screening, Pharmacogenomics, Proteomics, Array technology and Recombinant DNA technology of drugs. Disease targets for gene therapy. Monoclonal antibodies for diseases such as Diabetes, Cancer and neurodegenerative disorders.

Computational approaches for the quantification of Molecular diversity and design of compound libraries, physicochemical concept of in drug design. History of QSAR, 2D-QSAR; 3D-QSAR, descriptors of QSAR, Tools and techniques of QSAR, Parameters Used in QSAR, Applications of QSAR, 3D pharmacophore hypothesis.

Reading:

1. Textbook of Drug Design and Discovery. Fourth Edition, Author: PovlKrogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard.
2. Modern Methods of Drug Discovery. Gerhard Edwin Seibold, Alexander Hillisch, Rolf Hilgenfeld Publisher.
3. Modern Biopharmaceuticals: Design, Development and Optimization. 1st edition, JorgKnablein, Wiley – VCH, 2005.
4. Molecular Modeling, Principles & Applications. Andrew R.Leach, Addison Wesley Longman, Singapore, 1996.
5. Advanced Drug Design and Development. Kourounakis Taylor and Francis.

BT493	BIOPHYSICS	DEC	3 – 0 – 0	3 Credits

Prerequisites: BT202 Biochemistry

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the forces in biomolecules.
CO2	Understand configurational determinants and stabilizing factors of biomolecules
CO3	Understand the principles of all ostericity
CO4	Understand the biophysical fundamentals of enzyme catalysis
CO5	Understand the principles of membrane potential.

Mapping of the Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	1	-	-	-	-	-	-	-	3	3	-	-
CO2	3	2	-	1	-	-	-	-	-	-	-	2	3	-	-
CO3	3	2	-	2	-	-	-	-	-	-	-	3	3	-	-
CO4	3	3	1	2	-	-	-	-	-	-	-	3	3	-	-
CO5	3	2	1	2	-	-	-	-	-	-	-	3	3	-	-

Detailed Syllabus:

Molecular forces in biological structures: Intramolecular bonds – covalent – ionic and hydrogen bonds, Charge-dipole interactions, Induced dipoles, Cation-π interaction, hydration hydrophobic forces, Steric repulsions, Stabilizing forces in proteins and nucleic acids, Lipid bilayer and membrane proteins.

Conformation of macromolecules: Configurational partition functions and polymer chains, Random coils and effective length, Loop formation, Backbone rotation in proteins, Ramachandran Plot, Tertiary structures, The helix-coil transition, Cooperativity in protein folding.

Allosteric interactions: The allosteric transition, Energy balance in the one-site model, G-protein coupled receptors, Binding site interactions, Energetics of MWC model, Ligand gated channels, KNF and SK models.

Biophysics of enzyme catalysis: Michaelis -Menten Kinetics, Allosteric enzymes, Binding energy and Kramers' rate theory, Proximity, translational and rotational entropy, Friction in enzyme - substrate complex, Acid-base catalysis in enzymatic reactions.

Biophysics of biological membrane potential: Nernst and Donnan potentials, Membrane potentials of neurons and skeletal muscles, Membrane permeability of Na^+ and K^+, Using flux ratio and active transport, Membrane pumps, Surface charge and membrane potentials, Rate theory.

Reading:

1. Molecular and Cellular Biophysics by Meyer B. Jackson, Cambridge University Press, 1st ed, 2006.
2. Fundamentals and Techniques of Biophysics and Molecular Biology by Pranav Kumar, 2016.
3. A Text book of Biophysics. 2001. R N Roy

OPEN ELECTIVES

CE390	ENVIRONMENTAL IMPACT ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Identify the environmental attributes to be considered for the EIA study.
CO2	Formulate objectives of the EIA studies.
CO3	Identify the suitable methodology and prepare Rapid EIA.
CO4	Prepare EIA reports and environmental management plans.
CO5	Plan the methodology to monitor and review the relief and rehabilitation works.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO2	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO3	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO4	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-
CO5	2	1	2	-	-	3	3	1	-	2	1	-	-	-	-

Detailed Syllabus:

Introduction: The Need for EIA, Indian Policies Requiring EIA , The EIA Cycle and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA, Roles in the EIA Process. Government of India Ministry of Environment and Forest Notification (2000), List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements.

Identifying the Key Issues: Key Elements of an Initial Project Description and Scoping, Project Location(s), Land Use Impacts, Consideration of Alternatives, Process selection: Construction Phase, Input Requirements, Wastes and Emissions, Air Emissions, Liquid Effluents, Solid Wastes, Risks to Environment and Human, Health, Socio-Economic Impacts, Ecological Impacts, Global Environmental Issues.

EIA Methodologies**:** Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists methods, Matrices methods, Networks methods, Overlays methods, Environmental index using factor analysis, Cost/benefit analysis, Predictive or Simulation methods. Rapid assessment of Pollution sources method, predictive models for impact assessment, Applications for RS and GIS.

Reviewing the EIA Report: Scope, Baseline Conditions, Site and Process alternatives, Public hearing. Construction Stage Impacts, Project Resource Requirements and Related Impacts, Prediction of Environmental Media Quality, Socio-economic Impacts, Ecological Impacts, Occupational Health Impact, Major Hazard/ Risk Assessment, Impact on Transport System,Integrated Impact Assessment.

Review of EMP and Monitoring: Environmental Management Plan, Identification of Significant or Unacceptable Impacts Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation, Stipulating the Conditions, What should be monitored? Monitoring Methods, Who should monitor? Pre-Appraisal and Appraisal.

Case Studies: Preparation of EIA for developmental projects- Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, thermal plant, Nuclear fuel complex, Highway project, Sewage treatment plant, Municipal Solid waste processing plant, Tannery industry.

Reading:

1. Jain R.K., Urban L.V., Stracy G.S., *Environmental Impact Analysis*, Van Nostrand Reinhold Co., New York, 1991.

2. Barthwal R. R., *Environmental Impact Assessment*, New Age International Publishers, 2002

3. Rau J.G. and Wooten D.C., *Environmental Impact Assessment,* McGraw Hill Pub. Co., New York, 1996.

4. Anjaneyulu Y., and Manickam V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.

5. Wathern P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.

EE390	LINEAR CONTROL SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Analyze electromechanical systems using mathematical modelling
CO2	Determine Transient and Steady State behavior of systems using standard test signals
CO3	Analyze linear systems for steady state errors, absolute stability and relative stability
CO4	Design a stable control system satisfying requirements of stability and reduced steady state error

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2
CO2	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2
CO3	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2
CO4	3	3	2	-	-	1	-	-	-	-	-	-	1	3	2

Detailed syllabus:

Introduction: Control system, types, feedback and its effects-linearization

Mathematical Modeling of Physical Systems: Block diagram Concept and use of Transfer function. Signal Flow Graphs, Mason's gain formula.

Time Domain Analysis of Control Systems - BIBO stability, absolute stability, Routh-Hurwitz Criterion.

P, PI and PID controllers. Root Locus Techniques - Root loci theory,Application to system stability studies.

Introduction to state variables technique, Analysis of R-L, R-L-C networks.

Frequency Domain Analysis of Control Systems - polar plots, Nyquist stability criterion, Bode plots, application of Bode plots.

Reading:

1. B.C.Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
2. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co.2008.

EE391	SOFT COMPUTING TECHNIQUES	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the concepts of population based optimization techniques
CO2	Examine the importance of exploration and exploitation in heuristic optimization techniques to attain near-global optimal solution
CO3	Evaluate the importance of parameters in heuristic optimization techniques
CO4	Apply for the solution of multi-objective optimization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3
CO2	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3
CO3	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3
CO4	3	3	1	2	2	-	-	-	-	-	-	-	1	1	3

Detailed syllabus:

Fundamentals Of Soft Computing Techniques: Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

Genetic Algorithm And Particle Swarm Optimization: Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters. Application to SINX maximization problem.

Ant Colony Optimization And Artificial Bee Colony Algorithms: Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms.

Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm: Bat Algorithm- Echolocation of bats- Behavior of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs- comparison of memes and genes -memeplex formation- memeplex updation. Application to multi-modal function optimization Introduction to Multi- Objetive optimization-Concept of Pareto optimality.

Reading:

1. Xin-She Yang, “Recent Advances in Swarm Intelligence and Evolutionary Computation, Springer International Publishing, Switzerland, 2015.

2. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, John Wiley &

Sons, 2001.

3. James Kennedy and Russel E Eberheart, Swarm Intelligence, The Morgan Kaufmann Series in Evolutionary Computation, 2001.

4. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, Swarm Intelligence-From natural to Artificial Systems, Oxford university Press, 1999.

5. David Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Pearson Education, 2007.

6. Konstantinos E. Parsopoulos and Michael N. Vrahatis, Particle Swarm Optimization and Intelligence: Advances and Applications, Information science reference, IGI Global, 2010.

7. N P Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 2005.

ME390	AUTOMOTIVE MECHANICS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Analyze operation and performance indicators of transmission systems, internal combustion engines and after treatment devices.
CO2	Understand operation of engine cooling system, lubrication system, electrical system and ignition system.
CO3	Understand fuel supply systems in an diesel and petrol vehicles
CO4	Analyze current and projected future environmental legislation and its impact on design, operation and performance of automotive power train systems.
CO5	Understand operation and performance of suspension, steering and braking system.
CO6	Understand layout of automotive electrical and electronics systems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO2	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO3	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO4	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO5	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-
CO6	1	1	-	-	-	1	2	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Layout of an automotive chassis, engine classification.

Cooling Systems: Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulation systems, Components of water cooling systems- Radiator, thermostat etc.

Engine Lubrication: Petroils system, Splash system, Pressure lubrication and dry sump system

Ignition System: Battery, Magneto and Electronic, Engine Starting drives

Fuel supply system: Components in fuel supply system, types of feed pumps, air cleaners, fuel and oil filters, pressure and dry sump systems.

Engine testing and Performance: Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods

Automotive electrical and electronics: Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn.

Transmission: Clutch- Single and multiplate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

Suspension System: Front and rear suspension, shock absorbers, Rear Axles mountings, Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems.

Engine service: Engine service procedure.

Reading:

1. S. Srinivasan, Automotive Mechanics, Tata McGraw-Hill, 2004.
2. K.M. Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002
3. Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003.
4. William H. Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004
5. Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

ME391	ENTREPRENEURSHIP DEVELOPMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
CO4	Develop a framework for technical, economic and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO2	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO3	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO4	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO5	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO6	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-

Detailed syllabus

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Establishing Small Scale Enterprise: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

Planning a Small Scale Enterprises**:** Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Operational Issues in SSE**:** Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies**:** Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Reading:

1. G.G. Meredith, R.E. Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
2. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
3. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
4. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd Edition, Pearson Edu., 2013.

EC390	COMMUNICATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand different modulation and demodulation schemes for analog communications.
CO2	Design analog communication systems to meet desired application requirements
CO3	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
CO4	Elucidate design tradeoffs and performance of communications systems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-
CO2	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-
CO3	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-
CO4	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-

Detailed syllabus

Signal Analysis**:** Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density, Transmission of Random Process through an LTI Filter.

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Representation of Narrow Band noise In phase and Quadrature Components, Noise Figure, Noise Bandwidth, Noise Temperature.

Amplitude (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, DSB-SC Product Modulator, Switching Modulator, Ring Modulator, Coherent Detection, Costas receiver, SSB Signal Representation, Filtering Method, Phase Shift Method, Coherent Demodulation, VSB Modulator and Demodulator, Carrier Acquisition using Squaring Loop and Costas Loop, Receiver Model, SNR, Noise in SSB and DSB receivers using coherent detection, Noise in AM Receiver using Envelope detection, Threshold Effect.

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Transmission Bandwidth of FM Signals, Generation of FM using Direct and Indirect methods, FM Demodulation using Slope Circuit, Frequency Discriminator, Interference in Angle Modulation, Noise in FM Receiver, FM Threshold Effect, Pre-emphasis and De-emphasis in FM, Model of PLL for FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy, DM, DSM, Linear Prediction, DPCM, ADPCM, Noise in PCM System, Companding, Comparison of the Noise Performance of AM,FM,PCM and DM.

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, BSC Channel, Information Capacity Theorem, Bandwidth - Power Tradeoff, Huffman Coding.

Reading:

1. S. Haykin, Communication Systems, 4thEdn, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, 3rdEdition, Oxford University Press, Chennai, 1998.
3. Leon W. Couch II, Digital and Analog Communication Systems, 6thEdition, Pearson Education Inc., New Delhi, 2001.
4. A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, 4thEdition, MGH, New York, 2002.

EC391	MICROPROCESSOR SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Develop basic understanding of microprocessor architecture.
CO2	Design Microprocessor and Microcontroller based systems.
CO3	Understand C, C++ and assembly language programming
CO4	Understand concept of interfacing of peripheral devices and their applications

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-
CO2	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-
CO3	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-
CO4	1	1	1	-	2	-	-	-	-	-	-	-	-	1	-

Detailed syllabus

Microcomputer Organization: CPU, Memory, I/O, Operating System, Multiprogramming, Multithreading, MS Windows

80386 Micro Processors : Review of 8086,salient features of 80386,Architecture and Signal Description of 80386,Register Organization of 80386,Addressing Modes,80386 Memory management, Protected mode, Segmentation, Paging, Virtual 8086 Mode, Enhanced Instruction set of 80386, the Co- Processor 80387

Pentium & Pentium-pro Microprocessor: Salient features of Pentium microprocessor, Pentium architecture, Special Pentium registers, Instruction Translation look aside buffer and branch Prediction, Rapid Execution module, Memory management, hyper-threading technology, Extended Instruction set in advanced Pentium Processors

Microcontrollers: Overview of micro controllers-8051 family microcontrollers, 80196 microcontrollers family architecture, instruction set, pin out, memory interfacing.

ARM Processor Fundamentals: Registers, current Program Status Registers, Pipeline Exceptions, Interrupts and Vector Table, Architecture Revisions, ARM Processor families, ARM instruction set, Thumb Instruction set-Exceptions Handing, Interrupts, Interrupt Handling schemes, firmware, Embedded operating systems, Caches-cache architecture, Cache policy, Introduction to DSP on the ARM, DSP on the ARM7TDMI,ARM9TDMI.

Case study-Industry Application of Microcontrollers

Reading:

1. Barry B. Brey, Intel Microprocessor Architecture, Programming and Interfacing-8086/8088, 80186, 80286, 80386 and 80486, PHI, 1995.
2. Muhammad Ali Mazidi and Mazidi, The 8051 Microcontrollers and Embedded systems,PHI,2008
3. Intel and ARM Data Books on Microcontrollers.

MM364	FUNDAMENTALS OF MATERIALS PROCESSING TECHNOLOGY	OPC	3 – 0 –0	03 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Describe engineering materials.
CO2	Appreciate material processing techniques.
CO3	Select material processing technique for a given material and application.
CO4	Explain surface engineering techniques and their engineering significance.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-
CO2	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-
CO3	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-
CO4	3	3	2	-	-	1	1	-	-	-	-	-	1	1	-

Detailed syllabus

Introduction to engineering materials: Metals, alloys and phase diagrams, ferrous metals, non-ferrous metals, superalloys, guide to processing of metals; ceramics-structure and properties of ceramics, traditional ceramics, new ceramics, glass, some important elements related to ceramics; polymers-fundamentals of polymer science and technology, thermoplastic and thermosetting polymers, elastomers; composite materials-classification of composite materials, metal matrix, polymer matrix and ceramic matrix composites.

Fundamental properties of materials: mechanical properties-stress-strain relationships, hardness, tensile properties, effect of temperature on properties, visco-elastic behaviour of polymers, thermal properties and electrical properties of metals, polymers, ceramics and composites.

Metal casting fundamentals and metal casting processes: Overview of casting technology, melting and pouring, solidification and casting, sand casting, other expendable-mold casting processes, permanent-mold casting processes, casting quality, metals for casting.

Particulate processing of metals and ceramics: Powder metallurgy-characterization of engineering powders, production of metallic powders, conventional processing and sintering, alternative processing and sintering techniques, materials and products for powder metallurgy, design considerations in powder metallurgy, processing of traditional ceramics, processing of new ceramics, cermets and their processing.

Fundamentals of metal forming and shaping processes, such as rolling, forging, extrusion, drawing, sheet metal forming: Overview of metal forming, friction and lubrication in metal forming; bulk deformation processes in metal forming-rolling, other deformation processes related to rolling, forging, other deformation processes related to forging, extrusion, wire and bar drawing; cutting and bending operations, sheet-metal drawing, other sheet metal forming operations, dies and presses for sheet-metal processes, sheet-metal operations not performed in presses.

Fundamentals welding: Overview of welding technology, the weld joint, physics of welding, features of a fusion-welded joint; Welding processes-arc welding, resistance welding, oxy-fuel gas welding, other fusion welding processes, solid-state welding, weld quality, weldability; brazing, soldering and adhesive bonding.

Surface engineering and tribology: Importance of surface engineering, classification of surface engineering processes, introduction to thermal, mechanical, thermo-chemical and electro-chemical surface engineering processes with their advantages, limitations and applications.

Reading:

1. Kalpakjian and Schmid, Manufacturing Engineering and Technology, Prentice Hall, New Jersey, 2013.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, John Wiley & Sons, Inc., New Jersey, 2010.
3. DeGarmo, Black, and Kohser, Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York, 2011.
4. R. S. Parmar, Welding processes and Technology, Khanna Publishers, 2010.
5. H.S. Bawa, Manufacturing Technology-I, Tata McGraw Hill Publishers New Delhi, 2007.
6. Serope Kalpakjian, Manufacturing processes for Engineering Materials, Addison Wesley, 2001.

CH390	**NANOTECHNOLOGY AND APPLICATIONS**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the properties of nanomaterials
CO2	Synthesize nanoparticles
CO3	Characterize nanomaterials.
CO4	Scale up the production of nanoparticles
CO5	Evaluate safety and health related issues of nanoparticles

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															

Detailed Syllabus:

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nanosizes and properties comparison with the bulk materials, Different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Microemulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface charges, Zeta Potential and pH.

Carbon Nanomaterials: Synthesis of carbon bucky-balls, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones.

Quantum mechanics: Quantum dots and its Importance, Pauli exclusion principle, Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots Semi-conductor quantum dots

Nanomaterials characterization: Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential, Electronic band structure Electron statistics Application: Optical transitions in solids, photonic crystals, Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy.

Applications: Self-assembly and molecular manufacturing, Surfactant based system Colloidal system applications, Functional materials Applications, commercial processes of synthesis of nanomaterials.

Nanoinroganic materials of $CaCO_3$ synthesis, Hybrid Waste Water Treatments systems, Electronic Nanodevices,

Nanobiology: Biological synthesis of nanoparticles and applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nano materials, Environmental Impacts, Case Study for Environmental and Societal Impacts

Reading:

1. Kulkarni Sulabha K, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Gabor L. Hornyak, H.F. Tibbals, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
5. Davies, J.H., The Physics of Low Dimensional Semiconductors: An Introduction, Cambridge University Press, 1998.

CH391	INDUSTRIAL SAFETY MANAGEMENT	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Prerequisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Understand the methods of hazard identification and prevention.
CO4	Assess the risks using fault tree diagram.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															
CO6															

Detailed syllabus:

Introduction-Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, The Nature of the Accident Process, Inherent Safety.

Industrial Hygiene-Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Toxic Release and Dispersion Models-Parameters Affecting Dispersion, Neutrally Buoyant Dispersion Models, Dense Gas Dispersion, Toxic Effect Criteria, Effect of Release Momentum and Buoyancy, Release Mitigation.

Fires and Explosions-The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

Hazards Identification- Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

Risk Assessment- Review of Probability Theory, Event Trees, Fault Trees.

Safety Procedures: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures-Operating, Procedures-Permits, Procedures-Safety Reviews and Accident Investigations.

Reading:

1. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011.
2. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Elsevier India, Volume 6, 2006.

CH392	INDUSTRIAL POLLUTION CONTROL	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the effects of pollutants on the environment.
CO2	Distinguish air pollution control methods
CO3	Assess treatment technologies for wastewater
CO4	Identify treatment technologies for solid waste
CO5	Select treatment methodologies for hazardous and E-waste

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															

Detailed Syllabus:

Introduction: Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil.

Air pollution sources & effects: Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise.

Air pollution sampling and measurement: Types of pollutant sampling and measurement, Ambient air sampling, Stack sampling, Analysis of air pollutants.

Air pollution control methods & equipment: Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment.Control of specific gaseous pollutants: Control of NOx emissions, Control of hydrocarbons and mobile sources.

Water pollution: Water resources, Origin of wastewater, types of water pollutants and their effects.

Waste water sampling, analysis and treatment: Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, Advanced wastewater treatment, Recovery of materials from process effluents.

Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal.

Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

E-waste: Sources, environmental and social issues, management practices

Reading:

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke, Environmental Science and Engineering, Prentice Hall of India, 2nd Edition, 2004.
4. Rao M.N., Rao H.V.N, Air Pollution, Tata McGraw Hill Publishing Ltd., 1993.
5. De A.K., Environmental Chemistry, Tata McGraw Hill Publishing Ltd., 1999.
6. George Tchobanoglous, Franklin Louis Burton, H. David Stensel, Metcalf & Eddy, Inc., Franklin Burton, Waste Water Engineering: Treatment and Reuse, McGraw Hill Education; 4th Edition, 2003.
7. E-waste recycling, NPCS Board of consultants and Engineers, Asia pacific business press Inc. 2015

CH393	**SOFT-COMPUTING METHODS FOR CONTROL**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO2	Use neural networks to control the process plants
CO3	Develop fuzzy logic based controllers for different processes
CO4	Combine fuzzy logic with neural networks for plant control
CO5	Design controllers using genetic algorithms

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															

Detailed syllabus

Introduction to Artificial Neural Networks: Basic properties, Neuron Models, Feed forward networks.

Neural Networks Based Control: Representation and identification, modeling the plant, control structures – supervised control, Model reference control, Internal model control, Predictive control: Examples – Inferential estimation of viscosity an chemical process, Auto – turning feedback control.

Introduction to Fuzzy Logic: Fuzzy Controllers, Fuzzy sets and Basic notions – Fuzzy relation calculations – Fuzzy members – Indices of Fuzziness – comparison of Fuzzy quantities – Methods of determination of membership functions.

Fuzzy Logic Based Control: Fuzzy sets in commercial products – basic construction of fuzzy controller – Analysis of static properties of fuzzy controller – Analysis of dynamic properties of fuzzy controller – simulation studies – case studies – fuzzy control for smart cars.

Neuro – Fuzzy and Fuzzy – Neural Controllers: Neuro – fuzzy systems: A unified approximate reasoning approach – Construction of role bases by self-learning: System structure and learning.

Introduction to Genetic algorithms. Controller design using genetic algorithms.

Reading:

1. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, John Wiley & Sons, 2007.
2. Bose and Liang, Artificial Neural Networks, Tata McGraw Hill, 1996.
3. Huaguang Zhang, Derong Liu, Fuzzy Modeling and Fuzzy Control, Birkhauser Publishers, 2006.
4. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, 1992.
5. Lakshmi C. Jain, N. M. Martin, Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications, CRC Press, 1998.
6. MuhammetÜnal, AyçaAk, VedatTopuz, Hasan Erdal, Optimization of PID Controllers using Ant Colony and Genetic Algorithms, Springer, 2013.

CS390	OBJECT ORIENTED PROGRAMMING	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand fundamental concepts in object oriented approach.
CO2	Analyze design issues in developing OOP applications.
CO3	Write computer programs to solve real world problems in Java.
CO4	Analyze source code API documentations.
CO5	Create GUI based applications.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO2	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO3	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO4	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1
CO5	3	3	-	-	2	-	-	-	-	-	-	-	-	-	1

Detailed Syllabus:

Object- oriented thinking, History of object-oriented programming, overview of java, Object-oriented design, Structure of java program. Types and modifiers, Classes, declaring objects in classes, Methods, constructors, garbage collection, Method overloading, passing objects as parameters, Inheritance, various forms and types of inheritance, Multilevel hierarchy, use of super, method overriding, Applications of method overriding, abstract classes, Packages with examples

Interfaces and implementation, Exception handling, types, throwing, creating own exceptions, Multithreading and concepts, its usage and examples, Input/output streams, String operations and examples, Collection classes-array, stack collection, bitset collection, Utility classes-string tokenizer, bitset, date, Applets- methods, creation, designing and examples, Event handling-event classes, Event listener interfaces, AWT classes, working with frames, AWT controls-layout manager, user interface components, Graphics programming

Reading:

1. Timothy Budd, Understanding object-oriented programming with Java, Pearson, 2000.

2. Herbert Schildt, The complete reference Java 2, TMH, 2017.

BT390	GREEN TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Address smart energy and green infrastructure
CO2	Build models that simulate sustainable and renewable green technology systems
CO3	Understand the history, global, environmental and economical impacts of green technology
CO4	Address non-renewable energy challenges

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	2	3	1	-	-	-	-	3	2	1
CO2	3	3	3	1	1	2	3	-	-	-	-	-	3	2	2
CO3	3	3	3	1	1	2	3	-	-	-	-	-	3	2	2
CO4	3	3	2	2	2	2	3	1	-	-	-	-	3	2	3

Detailed Syllabus:

Biomass Energy, basic concepts, sources of biomass energy, uses of biomass energy, science and engineering aspects of biomass energy, production of biomass electricity, transmission of biomass electricity, storage of biomass electricity.

Energy transformation from source to services; Energy sources, sun as the source of energy; biological processes; photosynthesis; food chains, classification of energy sources, quality and concentration of energy sources; fossil fuel reserves - estimates, duration; theory of renewability, renewable resources; overview of global/ India's energy scenario.

Environmental effects of energy extraction, conversion and use; sources of pollution from energy technologies, Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends-process/product innovation-, technological/ environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity.

First and second laws of thermodynamics and their applications – Thermodynamic processes - Irreversibility of energy – Entropy. Properties of steam and classification of steam engines. Carnot cycle - Rankine cycle, Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil, Shale, Nuclear energy Option.

Biomass fuels, market barriers of biomass fuels, biomass fuel standardization, biomass fuel life cycle, Sustainability of biomass fuels, economics of biomass fuels, Fuel stoichiometry and analysis: Fuel stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O_2, CO_2, CO, NOx, SOx).

Biomass as a major source of energy in India: Fuel-wood use in rural households. Consequences for ecosystems. Future energy scenario in rural areas. Utilization of biomass in industrial and semi-industrial settings. Future utilization of biomass in India. Future of landscape management: optimal management.

Reading:

1. Ayhan Demirbas, Green Energy and Technology, Biofuels, Securing the Planet's Future Energy Needs, Springer, 2009.
2. Jay Cheng, Biomass to Renewable Energy Processes, CRC press, 2009.
3. Samir K. Khanal, Rao Y. Surampally, American Society of Civil Engineers, 2010.

SM390	MARKETING MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand concepts and scope of marketing and market oriented strategic planning
CO2	Analyze macro level environment
CO3	Identify factors influencing consumer behavior in competitive global business environment
CO4	Identify tools and techniques for marketing management through integrated marketing communication systems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO2	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO3	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO4	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-

Detailed Syllabus:

Importance of Marketing, Scope of Marketing, Core Marketing concepts company orientation towards market place-production concept, Product concept, selling concept and Marketing concept.

Market oriented Strategic planning – Defining corporate Mission and Vision Statement at Corporate level and at Business unit level. Assigning resources to Strategic Business units through B.C.G Matrix and G.E Model.

Analyzing Macro environment-Demographic environment. Economic Environment, Technical Environment, Social-Cultural Environment and political – Legal Environment.

Components of Marketing information systems- Internal Records, Marketing intelligence, Marketing research and Marketing Decision support system.

Consumer Behavior- Buying Decision process and the factors influencing consumer Behavior-Psychological factors, social factors, cultural factors and personal factors.

Importance of Market segmentation, Target market selection and positioning.

Importance of new product development process and the various stages involved.

The concept of product lifecycle and the various strategies used by the marketer in each stage. Product characteristics and classification, Product mix and product line decisions Branding Decisions, Building Brand Equity.

Importance of Pricing, Factors influencing pricing decisions. Various pricing methods-cost based and demand based methods.

Role of Marketing channels-Channel functions and channel levels channel Design and channel Management Decisions, Managing Retailing. Wholesaling and logistics. Importance of Electronic channels.

Importance of integrated Marketing communication. Advantages and Disadvantages of Various promotional tools- Advertising, Sales promotion, personal selling, publicity and public Relations and Direct marketing.

Reading:

1. Philip Kotler, Marketing Management, PHI, 14th Edition, 2013.
2. William Stonton & Etzel, Marketing Management, TMH, 13th Edition, 2013.
3. Rama Swamy & Namakumari, Marketing Management, McMillan, 2013.

MA390	NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Solve nonlinear differential equations by numerical methods.
CO2	Determine the convergence region for a finite difference method.
CO3	Solve elliptic PDE by finite difference method
CO4	Solve a parabolic PDE by finite difference method
CO5	Solve a hyperbolic PDE by finite difference method

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO2	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO3	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO4	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2
CO5	3	3	1	1	1	-	-	-	-	-	-	-	-	1	2

Detailed Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear and nonlinear boundary value problems, Quasi-linearization, Shooting methods

Finite difference methods: Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for Parabolic equations, Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem, stability analysis.

Hyperbolic Equations: Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods.

Elliptic equations: Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

Reading:

1. M.K. Jain, Numerical Solution of Differential Equations, Wiley Eastern, 1984.
2. G.D. Smith, Numerical Solution of Partial Differential Equations, Oxford Univ. Press, 2004.
3. M.K.Jain, S.R.K. Iyengar and R.K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2005.

MA391	FUZZY MATHEMATICS AND APPLICATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply operations on Fuzzy sets
CO2	Solve problems related to Propositional Logic.
CO3	Apply Fuzzy relations to cylindric extensions.
CO4	Apply logic of Boolean Algebra to switching circuits.
CO5	Develop Fuzzy logic controllers

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO2	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO3	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO4	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2
CO5	3	3	1	1	2	1	-	-	-	-	-	-	-	1	2

Detailed Syllabus:

Crisp set theory (CST): Introduction, Relations between sets, Operations on sets, Characteristic functions, Cartesian products of crisp sets, crisp relations on sets.

Fuzzy set theory (FST): Introduction, concept of fuzzy set (FS), Relation between FS, operations on FS, properties of standard operations, certain numbers associated with a FS, certain crisp sets associated with FS, Certain FS associated with given FS, Extension principle.

Propositional Logic (PL1): Introduction, Syntax of PL1, Semantics of PL1, certain properties satisfied by connectives, inference rules, Derivation, Resolution.

Predicate Logic (PL2): Introduction, Syntax of PL2, Semantics of PL2, certain properties satisfied by connectives and quantifiers, inference rules, Derivation, Resolution

-cuts of FR, Composition of FR, Projections of FR, Cylindric extensions, Cylindric closure, FR on a domain.

Fuzzy Logic (FL): Introduction, Three-valued logics, N-valued logics and infinite valued logics, Fuzzy logics, Fuzzy propositions and their interpretations in terms of fuzzy sets, Fuzzy rules and their interpretations in terms of FR, fuzzy inference, More on fuzzy inference, Generalizations of FL.

Switching functions (SF) and Switching circuits (SC): Introduction, SF, Disjunctive normal form, SC, Relation between SF and SC, Equivalence and simplification of circuits, Introduction of Boolean Algebra BA, Identification, Complete Disjunctive normal form.

Applications: Introduction to fuzzy logic controller (FLC), Fuzzy expert systems, classical control theory versus fuzzy control, examples, working of FLC through examples, Details of FLC, Mathematical formulation of FLC, Introduction of fuzzy methods in decision making.

Reading:

1. M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, PHI, 2001.
2. G.J. Klir and B.Yuan, Fuzzy sets and Fuzzy Logic–Theory and Applications, PHI, 1997.
3. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1995.

PH390	MEDICAL INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the origin of bio-potentials and their physical significance.
CO2	Understand anatomy and functioning of human heart and its common problems.
CO3	Analyze ECG, ENG and EMG signals and instrumentation.
CO4	Compare different techniques of measuring blood pressure, blood flow and volume.
CO5	Interpret the principle and operation of therapeutic and prosthetic devices.
CO6	Differentiate between the various techniques for measurement of parameters.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO2	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO3	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO4	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO5	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO6	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-

Detailed Syllabus:

General Introduction: The cell, body fluids, Musculoskeletal system, respiratory system, gastrointestinal system, Nervous system, endocrine system and circulatory system.

Origin of Bio potentials: electrical activity of Excitable cells: the resting state, The active state, Volume conductor fields, Functional organization of the peripheral nervous system: Reflex are & Junctional transmission.

The Electroneurogram (ENG): The H-Reflex, The Electromyogram (EMG), The Electrocardiogram (ECG), heart and the circulatory system, Electro conduction system of the heart and heart problems, ECG waveform and Physical significance of its wave features, Electrical behavior of cardiac cells, The standard lead system, The ECG preamplifier, DC ECG Amplier, Defibrillator protection circuit, Electro surgery Unit filtering, Functional blocks of

ECG system, Multichannel physiological monitoring system, Common problems encountered and remedial techniques.

Blood Pressure: indirect measurement of blood pressure, korotkoff sounds, auscultatory method using sphygmo manometer, Oscillometric and ultrasonic noninvasive pressure measurement, Direct measurement of blood pressure H2O manometers, electronic manometry, Pressure transducers,. Pressure amplifier designs, Systolic, diastolic mean detector circuits

Blood flow and Volume Measurement: indicator dilution methods, Transit time flow meter, DC flow meter, Electromagnetic flow meter AC electromagnetic flow meter, Quadrature suppression flow meter, Ultrasonic flow meter, Continuous-wave Doppler flow meter, Electric impedance plethysmography, chamber plethysmography, Photo plethysmography.

Pulse Oximetr: Principles of Operation, Absorption Spectrum, Sensor design, Pulse oximeter, Therapeutic and Prosthetic Devices.

Cardiac Pacemakers: Lead wires and electrodes, Synchronous Pacemakers, rate responsive pacemaking, Defibrillators, cardioverters, electrosurgical unit, Therapeutic applications of laser, Lithotripsy Haemodialysis.

Reading:

1. John G Webster, Medical Instrumentation: Application and Design, John Wiley, 3rd Edition, 2012.
2. Joseph J. Carr & John M. Brown , Introduction to biomedical Equipment Technology, 4th Edition, Prentice Hall India, 2001

PH391	ADVANCED MATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the synthesis and properties of nanomaterials
CO2	Evaluate the usefulness of nanomaterials in medicine, biology and sensing
CO3	Understand modeling of composite materials by finite element analysis
CO4	Differentiate superconducting materials
CO5	Understand the characteristics and uses of functional materials

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO2	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO3	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO4	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-
CO5	3	3	3	-	-	1	-	-	-	-	-	-	-	1	-

Detailed Syllabus:

Nano Materials: Origin of nanotechnology, Classification of nanomaterials, Physical, chemical, electrical, mechanical properties of nanomaterials. Preparation of nanomaterials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon nanotubes (CNT). Synthesis, preparation of nanotubes, nanosensors, Quantum dots, nanowires, nanobiology, nanomedicines.

Biomaterials: Overview of biomaterials. Biomaterials, bioceramics, biopolymers, tissue grafts, soft tissue applications, cardiovascular implants, biomaterials in ophthalmology, orthopedic implants, dental materials.

Composites: General characteristics of composites, composites classes, PMCs, MMCs, CMCs, CCCs, IMCs, hybrid composites, fibers and matrices, different types of fibers, whiskers, different matrices materials, polymers, metal, ceramic matrices, toughening mechanism, interfaces, blending and adhesion, composite modeling, finite element analysis and design.

Optical materials: Mechanisms of optical absorption in metals, semiconductors and insulators. Nonlinear optical materials, optical modulators, optical fibers. Display devices and materials photo-emissive, photovoltaic cells, charge coupled devices (CCD), laser materials.

Super conducting materials: Types of super conductors, an account of mechanism of superconductors, effects of magnetic field currents, thermal energy, energy gap, acoustic attenuation, penetration depth, BCS theory, DC and AC Josephson effects, high Tc superconductors, potential applications of superconductivity, electrical switching element, superconductor power transmission and transformers, magnetic mirror, bearings, superconductor motors, generators, SQUIDS etc.

Smart materials: An introduction, principles of smart materials, input – output decision ability, devices based on conductivity changes, devices based on changes in optical response, biological systems smart materials. Devices based on magnetization, artificial structures, surfaces, hetero structures, polycrystalline, amorphous, liquid crystalline materials.

Surface Acoustic Wave (SAW) Materials and Electrets: Delay lines, frequency filters, resonators, and Pressure and temperature sensors, Sonar transducers. Comparison of electrets with permanent magnets, Preparation of electrets, Application of electrets.

Reading:

1. T. Pradeep, Nano: The Essentials; TATA McGraw-Hill, 2008.
2. B.S. Murthy et al., Textbook of Nano science and Nanotechnology, University press, 2012.
3. Krishan K Chawla, Composite Materials; 2nd Edition, Springer 2006.

CY390	INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concepts of ultraviolet and visible absorption and fluorescence techniques for material characterization.
CO2	Understand the various liquid, gas and size-exclusion chromatographic techniques the automated continuous analysis of environmental, industrial, production-line materials
CO3	Understand the concepts of various electro analytical techniques for characterization of interfaces and traces of surface adsorbed-materials.
CO4	Understands the principles of thermogravimetry and differential thermal analyses (TGA and DTA) for applications into pharmaceuticals, drugs, polymers, minerals, toxins and in Finger Print Analysis
CO5	Identification of suitable analytical technique for characterization of chemical, inorganic and engineering materials

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO2	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO3	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO4	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-
CO5	3	3	-	3	1	1	1	-	-	-	-	-	1	2	-

Detailed Syllabus:

UV-Visible Spectrophotometry and Fluorescence: Beer-Lambert's law, limitations, Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods, applications.

Atomic spectrometry, atomic absorption, X-ray fluorescence methods: Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, X-ray fluorescence principle, instrumentation, quantitative analysis.

Chromatorgraphy methods: Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications. Capillary Electrophoresis: Principle and application.
Thermoanalytical methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications, Quantitative determinations
Electroanalytical methods: Coulometric methods, Polarography, Pulse voltammetric methods, Amperometry, Principles, Applications, Electrochemical sensors, Ion selective, Potentiometric and amperometric Sensors, Applications.
Spectroscopic methods: Molecular absorption, Woodward rules, applications, Infrared absorption, functional group analysis, qualitative analysis, 1H- and 13C-NMR spectroscopy, Principle, Basic instrumentation, terminology, Interpretation of data, Quantitative applications
Mass spectrometry: Principles, Instrumentation, Ionization techniques, Characterization and applications.

Reading:

1. Gurdeep Chatwal and Sham Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House, 1986.
2. Skoog, Holler and Kouch, Instrumental methods of analysis, Thomson, 2007.
3. Mendham, Denny, Barnes and Thomas, Vogel: Text book of quantitative chemical analysis, Pearson, 6Edotion, 2007.
4. William Kemp, Organic spectroscopy, McMillan Education, UK, 1991.
5. Instrumental methods of analysis – Willard, Meritt and Dean, PHI, 2005.

HS390	SOFT SKILLS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand corporate communication culture
CO2	Prepare business reports and proposals expected of a corporate professional
CO3	Employ appropriate speech in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Acquire corporate email, mobile and telephone etiquette

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO2	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO3	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO4	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO5	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-

Detailed Syllabus:

English Language Enhancement: Verbs and tenses, Phrasal verbs, Synonyms, Antonyms, Homonyms - Descriptive Words, Combining Sentences, Business Idioms, Indianisms in English.

Art of Communication, Communication process- Non-verbal Communication- Effective Listening.

Interpersonal and Intra Personal Communication Skills- Self-Awareness- Self-Esteem and Confidence- Assertiveness and Confidence- Dealing with Emotions-Team Concept- Elements of Teamwork- Stages of Team Formation- Effective Team-Team Player Styles- Leadership.

Campus to Company- Dressing and Grooming- The Corporate Fit- Business Etiquette- Communication; media etiquette- Group Discussions, Interviews, and Presentation Skills.

Interview handling skills- Effective Resume-- Common Interview Mistakes- Body-language- Content Aid, Visual Aids- Entrepreneurial Skills Development.

Reading:

1. Robert M. Sherfield, Developing Soft Skills, Montgomery and Moody 4th Edition, Pearson, 2009.
2. K. Alex, Soft Skills: Know Yourself & Know The world, S. Chand; 2009.
3. Robert Bramson, Coping with Difficult People, Dell, 2009.

CE440	BUILDING TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Apply basic principles to develop stable, sustainable and cost-effective building plans
CO2	Identify different materials, quality and methods of fabrication & construction.
CO3	Adopt standard building provisions for natural ventilation and lighting.
CO4	Identify effective measures for fire proofing, damp proofing, and thermal insulation.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-
CO3	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-
CO4	2	2	1	-	-	1	1	-	-	-	-	-	-	-	-

Detailed Syllabus:

Overview of the course, basic definitions, Buildings – Types, components, economy and design, Principles of planning of buildings and their importance. Definitions and importance of Grouping and circulation; Lighting and ventilation; How to consider these aspects during planning of building.

Termite proofing: Inspection, control measures and precautions, Lightning protection of buildings: General principles of design of openings, various types of fire protection measures to be considered while planning a building.

General requirements and extra requirements for safety against fire, special precautions, Vertical transportation in building – types of vertical transportation, Stairs, different forms of stairs, planning of stair cases, Other modes of vertical transportation – lifts, ramps, escalators.

Prefabrication systems in residential buildings – walls, openings, cupboards, shelves etc., planning and modules and sizes of components in prefabrication. Planning and designing of residential buildings against the earthquake forces, Principles, Seismic forces and their effect on buildings.

Air conditioning – process and classification of air conditioning, Dehumidification. Systems of air-conditioning, ventilation, functional requirements of ventilation.

Acoustics, effect of noise, properties of noise and its measurements, Principles of acoustics of building. Sound insulation – importance and measures.

Plumbing services – water supply system, maintenance of building pipe line, sanitary fittings, principles governing design of building drainage.

Reading:

1. Building Construction - Varghese, PHI Learning Private Limited, 2008.
2. Building Construction - Punmia, B C, Jain, A J and Jain A J, Laxmi Publications, 2005.
3. Building Construction by S.P. Arora and S.P. Bindra – Dhanpatrai and Sons, New Delhi, 1996.
4. Building Construction – Technical Teachers Training Institute, Madras, Tata McGraw Hill, 1992.
5. National Building code of India, Bureau of Indian Standards, 2005.

EE440	NEW VENTURE CREATION	OPC	3–0– 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the process and practice of entrepreneurship and new venture creation
CO2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO3	Explore the opportunities in the domain of respective engineering disciplines for launching a new venture
CO4	Expose the students with the functional management issues of running a new venture

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO2	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO3	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-
CO4	-	-	-	-	-	3	1	3	2	2	3	-	1	2	-

Detailed syllabus:

Entrepreneur and entrepreneurship: Entrepreneurship and Small Scale Enterprises (SSE), Role in Economic Development, Entrepreneurial Competencies, and Institutional Interface for SSE.

Establishing The Small Scale Enterprise: Opportunity Scanning and Identification,Market Assessment for SSE, Choice of Technology and Selection of Site, Financing the New/Small Enterprises, Preparation of the Business Plan, Ownership Structures and Organizational Framework.

Operating the Small Scale Enterprises: Financial Management Issues in SSE, Operational Management Issues in SSE, Marketing Management Issues in SSE, and Organizational Relations in SSE.

Reading:

1. Holt, Entrepreneurship: New Venture Creation, PHI (P), Ltd., 2001.
2. Madhulika Kaushik: Management of New & Small Enterprises, IGNOU course material, 1995

3. B S Rathore S Saini: Entrepreneurship Development Training Material, TTTI, Chandigarh, 1988.
4. P.C. Jain: A Hand Book for New Entrepreneurs, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
5. J.B. Patel, D.G Allampalli: A Manual on How to Prepare a Project Report, EDII, Ahmedabad, 1991.
6. J B Patel, S S Modi, A Manual on Business Opportunity Identification and Selection, EDII, Ahmedabad, 1995.

EE441	PRINCIPLES OF ELECTRIC POWER CONVERSION	OPC	3–0– 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the basics in the electric power conversion using power switching devices
CO2	Evaluate the conversion for range of renewable energy sources with the help of available electrical machines drives
CO3	Analyze the different energy storage systems
CO4	Identify the various Industrial and domestic applications

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-
CO2	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-
CO3	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-
CO4	1	2	1	1	1	1	1	-	-	-	-	-	1	2	-

Detailed syllabus:

Power Electronic Devices and Converters: V-I characteristics of SCR, MOSFET and IGBT. Phase controlled rectifiers, DC-DC converters and Inverters.

Applications to Electric Drives: Speed control of DC motor, Induction motors, PMSM and BLDC drives

Applications to Renewable Energy: Introduction to solar cell, solar panels, MPPT, wind and other renewable energy sources, Integration of renewable energy sources to the grid.

Energy Storage Systems: Study of automotive batteries, SMF, pumped storage systems, super-capacitors, fly wheels - applications, Li-ion batteries and applications to electric vehicles.

Domestic And Industrial Applications: Induction heating, melting, hardening, lighting applications and their control, UPS, battery chargers

Reading:

1. M.H.Rashid: Power Electronics-circuits, Devices and applications, Prentice Hall India, New Delhi, 2009.
2. P.S.Bhimbra: Power Electronics, Khanna publishers, New Delhi, 2012.
3. Ned Mohan, Undeland and Robbin: Power electronics converters, applications and design, John Willey & Sons, New York, 2006.

ME440	ALTERNATIVE SOURCES OF ENERGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify renewable energy sources and their utilization.
CO2	Understand basic concepts of solar radiation and analyze solar thermal systems for its utilization.
CO3	Understand working of solar cells and its modern manufacturing technologies.
CO4	Understand concepts of Fuel cells and their applications
CO5	Identify methods of energy storage.
CO6	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO2	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO3	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO4	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO5	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2
CO6	2	-	2	-	-	3	3	-	-	-	-	-	1	2	2

Detailed Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Global warming; Introduction to Renewable Energy Technologies

Energy Storage: Introduction; Necessity of Energy Storage; Energy Storage Methods

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems. Wind Energy: Introduction; Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

Fuel cells: Overview; Classification of fuel cells; operating principles; Fuel cell thermodynamics

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

Other forms of Energy: Introduction: Nuclear, ocean and geothermal energy applications; Origin and their types; Working principles

Reading:

1. Sukhatme S.P. and J.K. Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources, Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

ME441	ROBUST DESIGN	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand stages in engineering design and concept of robust design.
CO2	Develop quality loss functions and S/N ratios for S, N and L type objective functions.
CO3	Identify control and noise factors for a given product or process.
CO4	Conduct experiments using DOE concepts to decide the optimal setting of parameters
CO5	Apply quality loss function approach for fixing the component tolerances.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO2	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO3	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO4	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1
CO5	1	1	3	2	1	-	2	-	-	-	-	-	-	1	1

Detailed syllabus

Introduction: Taguchi's quality philosophy, causes of performance variation, concept of robust design, stages in product/process design, need for experimentation, QFD, process flow analysis, cause and effect diagram.

Design of Experiments**:** Principles of experimentation, Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA, Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Parameter Design**:** Loss function, average quality loss, S/N ratios, objective functions, selection of control & noise factors and their levels, strategy for systematic sampling of noise, classification of control factors, inner-array and outer-array design, data analysis, selection of optimum levels/values for parameters.

Tolerance Design: Experiments, selection of tolerances to be tightened, fixing the final tolerances.

Reading:

1. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000.
2. Ross PJ, Taguchi Techniques for Quality Engineering, TMH, 2005.

EC440	ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Apply knowledge of instruments for effective use
CO2	Select suitable instruments for typical measurements.
CO3	Identify various transducers to measure strain, temperature and displacement.
CO4	Understand data acquisition system and general purpose interfacing bus.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-
CO2	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-
CO3	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-
CO4	2	2	1	-	1	1	1	-	-	-	-	-	1	2	-

Detailed syllabus

Measurement And Error: Sensitivity, Resolution, Accuracy and precision, absolute and Relative types of errors, Statistical analysis, Probability of and Limiting errors, Linearity.

Instruments: D'Arsonval movement and basic principles of Measurement of Voltage, Current and Resistance in instruments. Analog and Digital Multimeters, Measurement of time and Frequency – Digital Frequency Meter and applications.

Impedance Measurement: Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q-meter; Noise and Interference reduction techniques in Measurement Systems.

Oscilloscopes: Block diagram, probes, Deflection amplifier and delay line, Trigger Generator, Coupling, Automatic Time Base and Dual Trace Oscilloscopes, Pulse Measurements, Delayed Time Base, Analog Storage, Sampling and Digital Storage Oscilloscopes.

Special instruments: Wave Analyzer, Harmonic Distortion Analyzer, Spectrum Analyzer, FFT Analyzer.

Transducers (Qualitative Treatment Only): Classification and selection of Transducers, Introduction to strain, Load, force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements.

Introduction to Data Acquisition Systems (DAS): Block Diagram, Specifications and various components of DAS.

General purpose Instrumentation Bus (GP-IB): Protocol, SCPI Commands and Applications to DSO and DMM.

Reading:

1. Oliver and Cage, Electronic Measurements and Instrumentation, McGraw Hill, 2009
2. Helfrick Albert D. and Cooper William D., Electronic Instrumentation & Measurement Techniques, PHI, 2008.
3. D.A. Bell, Electronic Instrumentation and Measurements, 3rd Edition, Oxford, 2013.

MM499	METALLURGY FOR NON-METALLURGISTS	OPC	3-0-0	03 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Discuss the characteristics and applications of metals and alloys.
CO2	Explain different fabrication techniques.
CO3	Correlate the microstructure, properties, processing and performance of materials.
CO4	Select metal/alloy for engineering applications.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-
CO2	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-
CO3	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-
CO4	2	2	1	-	1	1	1	-	-	-	-	-	1	1	-

Detailed syllabus

Introduction to Metallurgy: Metals and Alloys classification, engineering applications of metals/alloys.

Structure of Metals and Alloys: Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals.

Mechanical Properties: Plastic Deformation Mechanisms, Tensile, Creep, Fatigue, Fracture

Strengthening Mechanisms: Strain Hardening, Grain Size Refinement, Solid Solution Strengthening, Precipitation Hardening

Fabrication and Finishing of metal products: Metal Working and Machining

Testing of Metals: Destructive and Non-Destructive Testing, Inspection and Quality Control of Metals.

Engineering Alloys: Steel Products and Properties, Cast Irons, Tool Steels and High Speed Steels, Stainless Steels, selective non-ferrous metals and alloys.

Heat Treatment: Annealing, Normalizing, Hardening and Tempering.

Material selection processes: Case studies

Reading:

1. M. F. Ashby, Engineering Metals, 4th Edition, Elsevier, 2005.

2. R. Balasubramaniam (Adapted): Calister's Materials Science and Engineering, 7^{th} Edition, Wiley India (P) Ltd, 2007.
3. R. Abbaschian, L. Abbaschian, R.E. Reed-Hill, Physical Metallurgy Principles, East-West Press, 2009.
4. V Raghavan, Elements of Materials Science and Engineering- A First Course, 5^{th} Edition, PHI Publications, 2011

CH440	DATA DRIVEN MODELLING	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify disturbance models
CO2	Estimate parametric and non-parametric models
CO3	Determine the model structure
CO4	Validate the developed models

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3
CO2	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3
CO3	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3
CO4	2	2	1	2	2	-	-	-	-	-	-	1	-	-	3

Detailed syllabus

System Identification - Motivation and Overview. Models of Discrete-Time LTI Systems – Convolution equation. Difference equations, Transfer functions, State-space models, Discretization, Sampling and Hold operations, sampling theorem.

Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models. Parametric model structures - ARX, ARMAX, OE, BJ and PEM – structures and their applicability in real-time.

Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation and properties.

Estimation of non-parametric models - impulse / step response coefficients, frequency response models.

Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method.

Model Structure Selection and Diagnostics -estimation of delay and order, residual checks, properties of parameter estimates, model comparison and selection, model validation.

Reading:

1. Arun K. Tangirala. System Identification: Theory and Practice, CRC Press, 2014.

2. Karel J. Keesman, System Identification – An Introduction, Springer, 2011.
3. Nelles, O. Nonlinear System Identification, Springer-Verlag, Berlin, 2001.
4. Zhu, Y. Multivariable System Identification for Process Control, Pergamon, 2001.
5. Ljung, L. System Identification: Theory for the User, Prentice-Hall, 2^{nd} Edition, 1999.
6. J. R. Raol, G. Girija, J. Singh, Modeling and Parameter Estimation of Dynamic Systems, The Institution of Electrical Engineers, 2004.
7. Rolf Johansson, System Modeling and Identification, Prentice Hall, 1993.

CH441	**FUEL CELL TECHNOLOGY**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand fuel cell fundamentals.
CO2	Analyze the performance of fuel cell systems.
CO3	Demonstrate the operation of fuel cell stack and fuel cell system.
CO4	Apply the modeling techniques for fuel cell systems

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											
CO5															
CO6															

Detailed syllabus

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal , Using renewable fuels for SOFCs

Reading:

1. Hoogers G, Fuel Cell Technology Hand Book, CRC Press, 2003.
2. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, 2006.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, 2nd Edition, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications
5. Laminie J, Dicks A, Fuel Cell Systems Explained, 2nd Edition, John Wiley, New York, 2003.

CH442	**DESIGN OF EXPERIMENTS**	**OPC**	**3 – 0 – 0**	**3 Credits**

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design experiments for a critical comparison of outputs
CO2	Propose hypothesis from experimental data
CO3	Implement factorial and randomized sampling from experiments
CO4	Estimate parameters by multi-dimensional optimization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											

Detailed syllabus

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments.

Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

Experiments with Single Factor; An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparameteric methods in the analysis of variance, Problems.

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments.

Parameter Estimation.

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second-order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface designs, Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems.

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

Reading:

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5thEdition, 2010.
4. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995.

CH443	CARBON CAPTURE, SEQUESTRATION AND UTILIZATION	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the necessity of CO_2 capture, storage and utilization
CO2	Distinguish the CO_2capture techniques
CO3	Evaluate CO_2 Storage and sequestration methods
CO4	Assess Environmental impact of CO_2 capture and utilization

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4				`											

Detailed syllabus

Introduction: Global status of CO_2 emission trends, Policy and Regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U)

CO_2 capture technologies from power plants: Post-combustion capture, Pre-combustion capture, Oxy-fuel combustion, chemical looping combustion, calcium looping combustion

CO_2 capture agents and processes: Capture processes, CO_2 capture agents, adsorption, ionic liquids, metal organic frameworks

CO_2 storage and sequestration: Geological sequestration methods, Biomimetic carbon sequestration

CO_2 Utilization: CO_2 derived fuels for energy storage, polymers from CO_2, CO_2 based solvents, CO_2 to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis

Environmental assessment of CO_2 capture and utilization: Need for assessment, Green chemistry and environmental assessment tools, Life cycle assessment (LCA), ISO standardization of LCA, Method of conducting an LCA for CO_2 capture and Utilization.

Reading:

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the Carbon Cycle, Elsevier, 2015.

2. Goel M, Sudhakar M, Shahi RV, Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, TERI, Energy and Resources Institute, 2015.

3. Amitava Bandyopadhyay, Carbon Capture and Storage, CO_2 Management Technologies, CRC Press, 2014.

4. Fennell P, Anthony B, Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO_2) Capture, Woodhead Publishing Series in Energy: No. 82, 2015.

5. Mercedes Maroto-Valer M, Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Vol 2, Woodhead Publishing Series in Energy, 2014.

CS440	MANAGEMENT INFORMATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Determine key terminologies and concepts including IT, marketing, management, economics, accounting, finance in the major areas of business.
CO2	Design, develop and implement Information Technology solutions for business problems.
CO3	Analysis of computing systems and telecommunication networks for business information systems.
CO4	Understand ethical issues that occur in business, evaluate alternative courses of actions and evaluate the implications of those actions.
CO5	Plan projects, work in team settings and deliver project outcomes in time.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	1		3	-	-	2	-	-	2	-	1	-	-
CO2	-	-	1		3	-	-	2	-	-	2	-	1	-	-
CO3	-	-	1		3	-	-	2	-	-	2	-	1	-	-
CO4	-	-	1		3	-	-	3	-	-	2	-	1	-	-
CO5	-	-	1		3	-	-	2	-	-	3	-	1	-	-

Detailed syllabus

Organization and Information Systems, Foundation Concepts, Information Systems in Business, the Components of Information Systems, Competing with Information Technology, Fundamentals of Strategic Advantage, Using Information Technology for Strategic Advantage. Changing Environment and its impact on Business, Kinds of Information Systems.

Computer Fundamentals, Computer Hardware, and Computer Systems: End User and Enterprise Computing, Computer Peripherals: Input, Output, and Storage Technologies, Computer Software, Application Software, System Software, Computer System Management, Data Resource Management, Technical Foundations of Database Management, Managing Data Resources

Telecommunication and Networks, Telecommunications and Networks, the Networked Enterprise, Telecommunications Network Alternatives System Analysis and Development and Models, Developing Business/IT Strategies, Planning Fundamentals, Implementation

Challenges, Developing Business/IT Solutions, Developing Business Systems, Implementing Business Systems Manufacturing and Service Systems Information systems for Accounting, Finance, Production and Manufacturing, Marketing and HRM functions, Enterprise Resources Planning (ERP), Choice of IT, Nature of IT decision, Managing Information Technology, Managing Global IT, Security and Ethical Challenges, Security and Ethical Challenges, Security and Ethical, and Societal Challenges of IT, Security Management of Information Technology, Enterprise and Global Management of Information Technology.

Reading:

1. Kenneth J Laudon, Jane P. Laudon, Management Information Systems, 10th Edition, Pearson/PHI, 2007.

2. W. S. Jawadekar, Management Information Systems, 3rd Edition, TMH, 2004.

BT440	BIOSENSORS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand biosensing and transducing techniques
CO2	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
CO3	Demonstrate appreciation for the technical limits of performance of biosensor
CO4	Apply principles of engineering to develop bioanalytical devices and design of biosensors

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO2	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO3	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-
CO4	3	2	2	-	1	2	-	-	-	-	-	-	1	-	-

Detailed Syllabus:

General principles: A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; piezoelectric transducers.

Biorecognition systems: Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Tissue and organelles (animal and plant tissue); Cell culture; Immunoreceptors; Chemoreceptors; Limitations & problems. Immobilization of biomolecules.

Biosensor Engineering: Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS. Engineering concepts for mass production.

Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations.

Reading:

1. Donald G. Buerk, Biosensors: Theory and Applications, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1998.
3. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003.

SM440	HUMAN RESOURCE MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand principles, processes and practices of human resource management.
CO2	Apply HR concepts and techniques in strategic planning to improve organizational performance.
CO3	Understand tools to manage HR systems and procedures.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO2	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-
CO3	2	2	-	-	-	-	-	-	2	1	2	-	-	-	-

Detailed Syllabus:

Introduction to Human Resource Management, Objectives, Scope and Significance of HRM, Functions of HRM, Problems and Prospects in HRM, Environmental scanning.

Human Resource Planning, Demand Forecasting Techniques, Supply Forecasting Techniques, Analyzing work and designing jobs, Recruitment and Selection, Interviewing Candidates.

Human Resource Development, Orientation, Training and Development, Management, Development, Performance Appraisal and Employee Compensation, Factors Influencing, Employee Remuneration and Challenges of Remuneration.

Industrial Relations, Industrial Disputes and Discipline, Managing Ethical Issues in Human Resource Management, Workers Participation in Management, Employee safety and health, Managing Global Human Resources and Trade Unions

International HRM, Future of HRM and Human Resource Information Systems

Reading:

1. Aswathappa, Human Resource Management — TMH, 2010.
2. Garry Dessler and BijuVarkkey, Human Resource Management, PEA, 2011.
3. Noe & Raymond, HRM: Gaining a Competitive Advantage, TMH, 2008.
4. Bohlander George W, Snell Scott A,Human Resource Management, Cengage Learning, 2009.

MA440	OPTIMIZATION TECHNIQUES	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Formulate and solve linear Programming Problems
CO2	Determine the optimum solution to constrained and unconstrained
CO3	Apply dynamic programming principle to Linear programming problems.
CO4	Determine the integer solutions to Linear Programming Problems.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO2	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO3	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO4	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3

Detailed Syllabus:

Linear Programming: Introduction and formulation of models, Convexity, Simplex method, Big-M method, Two-phase method, Degeneracy, non-existent and unbounded solutions, revised simplex method, duality in LPP, dual simplex method, sensitivity analysis, transportation and assignment problems, traveling salesman problem .

Nonlinear Programming: Introduction and formulation of models, Classical optimization methods, equality and inequality constraints, Lagrange multipliers and Kuhn-Tucker conditions, quadratic forms, quadratic programming problem, Wolfe's method.

Dynamic Programming: Principle of optimality, recursive relations, solution of LPP.

Integer Linear Programming: Gomory's cutting plane method, Branch and bound algorithm, Knapsack problem, linear 0-1 problem.

Reading:

1. Kanti Swarup, Man Mohan and P.K. Gupta, Introduction to Operations Research, S. Chand & Co., 2006

2. J.C.Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.

3. N.S. Kambo, Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

MA441	OPERATIONS RESEARCH	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Formulate and solve linear programming problems
CO2	Determine optimum solution to transportation problem
CO3	Determine average queue length and waiting times of queuing models.
CO4	Determine optimum inventory and cost in inventory models.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO2	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO3	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3
CO4	3	3	1	1	2	-	-	-	-	-	-	-	-	-	3

Detailed Syllabus:

Linear Programming: Formulation and graphical solution of LPP's. The general LPP, slack, surplus and artificial variables. Reduction of a LPP to the standard form. Simplex computational procedure, Big-M method, Two-phase method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems.

Transportation Problems: Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions.Degenracy in Transportation problems. Queueing Theory: Poisson process and exponential distribution. Poisson queues - Model (M/M/1):(∞/FIFO) and its characteristics.

Elements of Inventory Control: Economic lot size problems - Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages - production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand (discrete case only).

Reading:

1. K. Swarup, Manmohan & P.K. Gupta, Introduction to Operations Research, S. Chand &

Co., 2006

2. J.C. Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.

3. N.S. Kambo: Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

PH440	NANOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand synthesis and properties of nanostructured materials.
CO2	Analyze magnetic and electronic properties of quantum dots
CO3	Understand structure, properties and applications of Fullerenes and Carbon nanotubes.
CO4	Understand applications of nanoparticles in nanobiology and nanomedicine

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-
CO2	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-
CO3	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-
CO4	3	1	1	1	-	-	-	-	-	-	-	-	1	1	-

Detailed Syllabus:

General properties of Nano materials: Origin of nanotechnology. Classification of nanomaterials. Fullerene,carbon nanotubes (CNT's), Nanoparticles. Physical, Chemical, Electrical, Optical, Magnetic and mechanical properties of nanomaterials.

Fullerenes and Carbon Nanotubes (CNT's): Introduction: Synthesis and purification. Preparation of fullerenes in the condensed phase, Transport, mechanical, physical properties of CNT's.

Investigation and manipulating materials in the Nanoscale: Electron microscope, scanning probe microscopes, optical microscopes for Nanoscience and Technology, X-Ray Diffraction.

SAMs and clusters: Growth process. Patterning monolayers. Types of clusters. Bonding and properties of clusters.

Semi conducting Quantum Dots: Introduction: Synthesis of Quantum Dots. Electronic structure of Nanocrystals, properties.

Nanobiology: Interaction between Biomolecules and Nanoparticle surgaces. Different types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies. Nanoprobes for Analytical Applications.

Nanosensors: Nanosensors based on optical properties. Nanosensors based on quantum size effects. Nanobiosensors.

Nanomedicines: Developments of nanomedicines. Nanotechnology in Diagnostic Applications, materials for use in Diagnostic and therapeutic Applications.

Reading:

1. T. Pradeep, Nano: The Essentials; Tata McGraw-Hill, 2008.
2. W.R. Fahrner, Nanotechnology and Nanoelectronics; Springer, 2006.
3. Rechard Booker and Earl Boysen, Nanotechnology, Willey, 2006.

PH441	BIOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the structure and properties of biomaterials
CO2	Classify implant biomaterials
CO3	Evaluate biocompatibility of implants
CO4	Identify appropriate biomaterials for specific medical applications

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-
CO2	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-
CO3	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-
CO4	3	3	1	1	-	1	2	1	-	-	-	-	1	1	-

Detailed Syllabus:

Overview of biomaterials: Historical developments, impact of biomaterials, interfacial phenomena, tissue responses to implants.

Structure and properties of biomaterials: Crystal structure of solids, phase changes, imperfections in solids, non-crystalline solids, surface properties of solids, mechanical properties, surface improvements.

Types of biomaterials: Metallic implant materials, ceramic implant materials, polymeric implant materials composites as biomaterials.

Characterization of materials: Electric properties, optical properties, X-ray absorption, acoustic and ultrasonic properties.

Bio implantation materials: Materials in ophthalmology, orthopedic implants, dental materials and cardiovascular implant materials.

Tissue response to implants: Normal wound healing processes, body response to implants, blood compatibility, and structure – property relationship of tissues.

Reading:

1. Joon Park, R.S. Lakes, Biomaterials an introduction; 3rd Edition, Springer, 2007
2. Sujatha V Bhat, Biomaterials; 2nd Edition, Narosa Publishing House, 2006.

CY441	CHEMISTRY OF NANOMATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Demonstrate a systematic knowledge of the range and breadth of application of nanomaterials.
CO2	Review critically the potential impact, in all classes of materials, of the control of nanostructure
CO3	Describe the methods for the synthesis and nanostructural characterisation of such materials.
CO4	Identify the possible opportunities for nanomaterials in society development and enhancement.

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-
CO2	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-
CO3	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-
CO4	3	1	1	1	-	2	2	-	-	-	-	-	1	-	-

Detailed Syllabus:

Introduction: Review the scope of nanoscience and nanotecnology, understand the nanoscience in nature, classification of nanostructured materials and importance of nanomaterials.

Synthetic Methods: Teach the basic principles for the synthesis of Nanostructure materials by Chemical Routes (Bottom-Up approach):-Sol-gel synthesis, microemulsions or reverse micelles, solvothermal synthesis, microwave heating synthesis and sonochemical synthesis and Physical methods (Top-Down approach):- Inert gas condensation, plasma arc technique, ion sputtering, Laser ablation, laser pyrolysis, and chemical vapour deposition method.

Techniques for characterization: Learning of characterization method by various techniques like, Diffraction Technique:-Powder X-ray diffraction for particle size analysis, Spectroscopy Techniques:-Operational principle and applications of spectroscopy techniques for the analysis of nanomaterials, UV-VIS spectrophotometers and its application for band gap measurement, Electron Microscopy Techniques:-Scanning electron microscopy (SEM)and EDAX analysis, transmission electron microscopy (TEM), scanning probe microscopy (SPM)BET method for surface area determination and Dynamic light scattering technique for particle size analysis.

Studies of nano-structured Materials:Synthesis, properties and applications of the following nanomaterials: fullerenes, carbon nanotubes, core-shell nanoparticles, nanoshells, self-assembled monolayers, and monolayer protected metal nanoparticles, nanocrystalline materials.

Reading:

1. T Pradeep, NANO: The Essentials, MaGraw Hill, 2007.
2. B S Murty, P Shankar, BaldevRai, BB Rath and James Murday, Textbook of Nanoscience and nanotechnology, Univ. Press, 2012.
3. Guozhong Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Applications, Imperial College Press, 2007.
4. M.A. Shah and Tokeer Ahmad, Principles of Nanoscience and Nanotechnology, Narosa Pub., 2010.
5. Manasi Karkare, Nanotechnology: Fundamentals and Applications, IK International, 2008.
6. C. N. R. Rao, Achim Muller, K. Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.

HS440	CORPORATE COMMUNICATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand corporate communication culture
CO2	Prepare business letters, memos and reports
CO3	Communicate effectively in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Practice corporate email, mobile and telephone etiquette
CO6	Develop good listening skills and leadership qualities

Course Articulation Matrix

PO / CO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO2	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO3	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO4	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO5	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-
CO6	-	-	-	-	-	-	-	3	1	3	2	-	-	-	-

Detailed Syllabus:

Importance of Corporate communication: Introduction to and definition of corporates – Communication, process, patterns and channels of communication- Barriers to communication and strategies to overcome them- Evolution of corporate culture- Role and contribution of individual group and organization - Role of psychology in communication.

Oral Communication: Techniques for improving oral fluency-Speech mechanics-Group Dynamics and Group Discussion – Debate and oral presentations.

Written Communication: Types and purposes- Writing business reports, and business proposals- Memos, minutes of meetings- Circulars, persuasive letters- Letters of complaint- ; language and formats used for drafting different forms of communication. Internal and external communication.

Corporate responsibility: Circulating to employees vision and mission statements- ethical practices- Human rights -Labour rights-Environment- governance- Moral and ethical debates surrounding -Public Relations - Building trust with stakeholders.

Corporate Ethics and Business Etiquette: Integrity in communication-Harmful practices and communication breakdown- Teaching how to deal with tough clients through soft skills. Body language- Grooming- Introducing oneself- Use of polite language- Avoiding grapevine and card pushing – Etiquette in e-mail, mobile and telephone.

Listening Skills: Listening- for information and content- Kinds of listening- Factors affecting listening and techniques to overcome them- retention of facts, data and figures- Role of speaker in listening.

Leadership Communication Styles: Business leadership -Aspects of leadership-qualities of leader- training for leadership-delegation of powers and ways to do it-humour-commitment.

Reading:

1. Raymond V. Lesikar, John D. Pettit, Marie E. FlatleyLesikar's Basic Business Communication - 7th Edition: Irwin, 1993

2. Krishna Mohanand Meera Banerji, Developing Communication Skills: Macmillan Publishers India, 2000

3. R.C. Sharma & Krishna Mohan Business Correspondence and Report Writing: – 3rd Edition Tata McGraw-Hill, 2008

4. Antony Jay & Ross Jay, Effective Presentation, University Press, 1999.

5. Shirley Taylor, Communication for Business, Longman, 1999.