B.M.S. COLLEGE OF ENGINEERING

(Autonomous college under VTU)

BENGALURU-560019

DEPARTMENT OF BIOTECHNOLOGY

Scheme &Syllabus for III – VIII Semester

With effect from the A.Y. 2019-20

INSTITUTE VISION & MISSION

VISION

Promoting Prosperity of mankind by augmenting human resource capital through quality Technical Education & Training

MISSION

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT VISION & MISSION

VISION

To be a Centre of excellence in the field of Biotechnology equipped to create graduates who endeavour for the welfare of mankind.

MISSION

- To impart quality education for life long professional growth and opportunity in a wide range of Careers.
- To create awareness towards socio-ethical implications of potentials of Biotechnology.

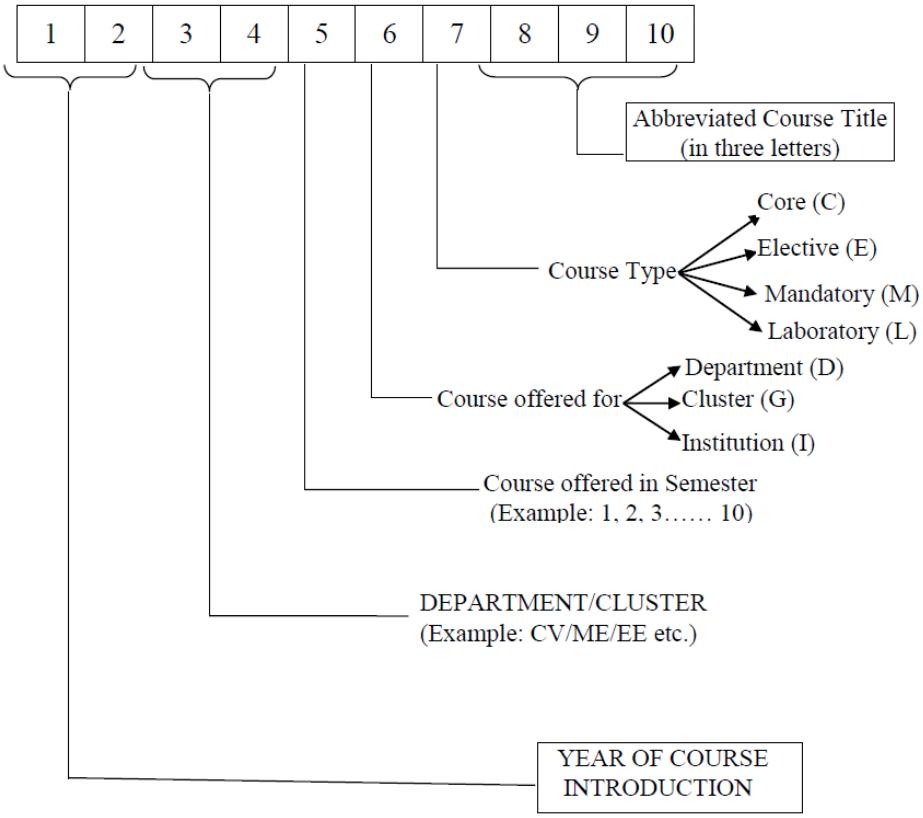
PROGRAMME OUTCOMES (POs)

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems :** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OBJECTIVES

PSO1	Apply knowledge of basic sciences and biotechnological techniques to manipulate living organisms.
PSO2	Design, optimize, analyse and scale up a bioprocess to develop value added products
PSO3	Generate, analyse and interpret Biological data using Insilco approaches.

NOMENCLATURE FOR THE COURSE CODE



III Semester Scheme

Course Type	Code	Course Title	Credits			Total Credits	Contact hours/ week	Marks		
			L	T	P			CIE	SEE	Total
HS-2	19BT4HSEVS	Environmental Studies	2	0	0	2	2	50	50	100
BS-5	19BT3ICMAT	Engineering Mathematics-III	3	1	0	4	5	50	50	100
PC-1	19BT3DCMBG	Microbiology	3	0	1	4	4	50	50	100
PC-2	19BT3DCBBM	Basics of Biomolecules	3	0	1	4	4	50	50	100
PC-3	19BT3DCPPC	Process Principles & Calculations	3	1	0	4	5	50	50	100
PC-4	19BT3DCBCA	Basics of computer applications	3	0	1	4	4	50	50	100
PC-5	19BT3DCUO1	Unit operations-1	3	0	0	3	3	50	50	100
SR-1	19BT3DCSEM	Seminar	0	0	1	1	1	50	50	100
TOTAL			**20**	**2**	**4**	**26**	**28**	**400**	**400**	**800**

IV Semester Scheme

Course Type	Code	Course Title	Credits			Total Credits	Contact hours/ week	Marks		
			L	T	P			CIE	SEE	Total
HS-1	19HS4ICCPH	Constitution of India and Professional Ethics	1	0	0	1	1	50	50	100
BS-6	19MA4BSBSP	Biostatistics & probability	3	1	0	4	5	50	50	100
ES-7	19BT4ESPET	Process Engg., Thermodynamics	3	1	0	4	5	50	50	100
PC-6	19BT4DCUO2	Unit Operations-2	3	0	1	4	4	50	50	100
PC-7	19BT4DCCMB	Cell & Molecular Biology	3	0	1	4	4	50	50	100
PC-8	19BT4DCBAB	Biochemistry & Bioenergetics	3	0	1	4	4	50	50	100
PC-9	19BT4DCIHC	Industrial handled course	1	0	0	1	1	50	50	100
SR-2	19BT4DCSEM	Seminar Based on Summer/Winter Internship	0	0	2	2	2	50	50	100
NC-3	19BT4NCCSP	Community service program	Non-credit mandatory Course							
TOTAL			**17**	**2**	**5**	**24**	**26**	**400**	**400**	**800**

Humanities and Social Sciences including Management Courses (HS); Basic Science Courses (BS); Engineering Science Courses (ES); Professional Core Courses (PC); Professional Elective Courses (PE); Open Electives (OE); Project Work (PW); Technical Seminar (SR); Internship in industry or Institution (IN); Non-Credit Mandatory Courses (NC).

DEPARTMENT OF BIOTECHNOLOGY

THIRD SEMESTER

Course Title	ENVIRONMENTAL STUDIES													
Course Code	1	9	H	S	4	P	C	E	V	S	Credits	02	L – T – P	2 – 0– 0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE OBJECTIVE:

1. To acquire the knowledge of environmental studies, it's need & importance
2. To understand the concept, structure and function of different ecosystems
3. To know about pollution problems and green technology
4. To develop a sense of responsibility about the role of students in fostering the idea of learning to live in harmony with nature.
5. To aware the studies about current conditions of environment
6. To give an opportunity to the student to experience the interdisciplinary nature of the environmental studies
7. To create interest in students about the environment through a project work
8. To encourage student to prevent the environmental degradation

COURSE OUTCOME:

CO1: Understand the components and impacts of human activities on environment.

CO2: Apply the environmental concepts for conservation and protection of natural resources.

CO3: Identify and establish relationship between social, economical and ethical values from environmental perspectives.

Unit – I : Introduction to Environment: [6L]

Definition about Earth, atmosphere, hydrosphere, lithosphere and biosphere.
Structure of Atmosphere : Troposphere, Stratosphere, Mesosphere,Ionosphere, Exosphere.
Internal structure of the Earth: Crust, Mantle, Core.
Ecosystem, types of Ecosystem: Land, Forest, Water, Desert, Marine.
Effects of Human activities on Environment: Agriculture, Housing, Industries, Mining and Transportation.

Unit-II: Natural Resources: [6L]

Water resources: availability, use and consequences of over utlisation, water conflicts.
Case studies
Mineral resources: Definition, types, environmental impact of mining
Forest resources: Uses, effects of deforestation, remedial measures
Energy resources: renewable and non-renewable, growing needs, types of energy resources: hydroelectric, wind power, fossil, solar, nuclear and bio gas.
Hydrogen as an alternate future source of energy

Unit-III: Environmental pollution [6L]

Introduction, causes, effects and control measures.
Water pollution, land pollution, noise pollution, air pollution and marine pollution-case studies.
Environmental management: Solid waste, hazardous waste, e-waste, bio medical waste

Unit-IV: Social issues and Environment [6L]

Population growth.
Climatic changes: Global warming, acid rain, ozone layer depletion.
Water conversation: rain water harvesting and ground water recharging.
Disaster management: floods, earthquakes, landslides-case studies
Environmental Protection Acts: Air, Water, land and Noise (Prevention and Control of pollution), Forest conservation, Wildlife protection.

TEXT BOOKS:

1. Environmental studies by - Dr. Geethabalakrishanan (Revised Edition)
2. Ecology by – Subramanyam (Tata McGraw Hill Publication)
3. Environmental studies by – Dr. J.P.Sharma (Third edition)
4. Environmental studies by – SmritiSrivastav

REFERENCES:

1. Environmental studies by – Benny Joseph
2. Environmental studies by – Dr. D.L.Manunath

LEARNING RESOURCES:

1. NPTEL (Open Sources / power point and visuals)
2. Ecological studies / IITR / Open Sources
3. Ministry of Environment and forest & wildlife.

MOOC's:
MOOCS – https://www.coursera.org / course / sustain

SEE PAPER PATTERN:

Sub: Environmental Studies (19HS4PCEVS)

SEE Question paper consist of two parts, Part –A consists of 40 MCQ'S, one mark each. Whereas Part –B consist of 5 main questions of 20 marks each.
Student should answer Part – A compulsory and any three full questions from Part-B, covering all units.

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	COURSE : EVSCODE: 19 HS4PCEVS														
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1			-											
CO2				-	1										-
CO3		1	-		-	-	-	-			-				

	COURSE : EVS				CODE : **19 HS4ICEVS**
Taxonomy Levels and COs	**Remember/ understand**	**apply**	**analyze**	**Design**	**Create or any other**
CO1	✓	-	-		
CO2		✓			
CO3		✓			

Course Title	Engineering mathematics	Course Code	19MA3IMMAT
Credits	4	L – T – P	3 – 1 – 0
Contact hours	48 hours (36L+12T)		

Prerequisites: Basic concepts of Trigonometry, methods of differentiation, methods of integration, solution of ordinary differential equations.

Course Objectives: The purpose of the course is to make the students conversant with concepts of Linear Algebraic systems, Fourierseries, Fourier Transforms and develop computational skills using efficient numerical methods for problems arising in science and engineering.

COURSE OUTCOME (CO)

CO 1 Apply Numerical techniques to solve problems arising in engineering.

CO 2 Demonstrate an understanding of Fourier Series, Fourier Transforms and Z- Transforms.

CO 3 Apply the concepts of calculus to functionals.

UNIT-1

MATRICES [9 hours]

Introduction: Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of a system of linear equations and solution. Solution of a system of non-homogenous equations: Gauss elimination method, Gauss-Seidel method, LU decomposition method, eigenvalues and eigenvectors of matrices, reduction of a matrix to diagonal form. (7L + 2T)

UNIT-2

FOURIER SERIES [9 hours]

Introduction: Dirichlet's conditions, Fourier series of periodic functions of period 2l, Fourierseries of functions having points of discontinuity. Applications: Fourier series of typical waveforms like saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform, exponential Fourier series, practical harmonic analysis. (7L + 2T)

UNIT-3

FOURIER TRANSFORMS [9 hours]

Infinite Fourier transform: Fourier Sine and Cosine transforms, properties, Inverse transforms. Convolution theorem, Parseval's identities. (6L + 3T).

UNIT-4

NUMERICAL METHODS [10 hours]

Solution of algebraic and transcendental equations: Newton-Raphson method. Finite Differences and interpolation: Forward differences, backward differences. Newton- Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical integration: Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule. Numerical solution of ordinary differential equations: modified Euler's method, Runge-Kutta method of fourth order. (8L + 2T)

UNIT-5

CALCULUS OF VARIATIONS [11 hours]

Variation of a functional, Euler's equation, variational problems.
Applications: Hanging cable problem, Brachistochrone problem.

Z -TRANSFORMS

Definition, Properties, Transforms of standard functions, Inverse transforms. Solution of difference equations using Z- transforms. (8L + 3T)

Text Books:

1. Higher Engineering Mathematics, B. S. Grewal, 43 Rd edition, 2014, Khanna Publishers.
2. Advanced Engineering Mathematics, 4th edition, 2011, Dennis G. Zill and Cullen, Jones and Bartlett India Pvt. Ltd.

Reference Books:

1. Higher Engineering Mathematics, B. V. Ramana, 2007, Tata McGraw Hill.
2. Advanced Engineering Mathematics, Erwin Kreyszig, 10 Th edition Vol.1 and Vol.2, 2014, Wiley- India.

E books and online course materials:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-993j-introduction-to-numerical-analysisfor-engineering-13-002j-spring-2005/lecture-notes/
2. https://www.pdfdrive.com/calculus-of-variations-e34313748.html

Online Courses and Video Lectures:

1. https://nptel.ac.in/courses/111103021/22 (Fourier series and Transforms, Heat and Wave Equations)
2. https://nptel.ac.in/courses/122104018/2 (Numerical Methods)
3. https://nptel.ac.in/courses/111104025/ (Calculus of variation)

Question Paper Pattern:

1. Five full questions to be answered.
2. To set one question each from units 1, 2, 4 and two questions each from Unit 3 and Unit 5.

Course Title	MICROBIOLOGY													
Course Code	1	9	B	T	3	D	C	M	B	G	Credits	04	L – T – P	3-0-1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Basics of biology, Biology for Engineers.

COURSE DESCRIPTION: The tiny microbes play essential role in each and everyone's life. This course will enable students to understand the diverse nature of microbial world. Also focusses on morphological and functional properties of Bacteria, Fungi, and Viruses. Uses laboratory experiments that stress aseptic techniques and that develop skills necessary to handle microbes, including the characterization of unknown microbes.

COURSE OBJECTIVES: The course emphasizes on historical perspective, types and distinctive features of tiny microbes. It deals with microscopic observations, invitro culturing, determination of growth and study of physico-chemical properties of various microorganisms. The course also provides knowledge of distinctive metabolic activities of microbes and their control.

PART A: THEORY

UNIT 1
DISTINCTIVE FEATURES AND OBSERVATION OF MICROORGANISMS [8L]
History of Microbiology, the Scope of Microbiology, Microbial diversity And Taxonomy (Numerical, Phylogenetic and Molecular approaches), Types of Microorganisms.
MICROSCOPY: Basic principle, microscopic parameters (resolving power, NA, magnification), Types: Bright-Field Microscopy, Dark-Field Microscopy, Phase-Contrast Microscopy, Fluorescence Microscopy, Electron Microscopy (principle, ray diagram, procedure and applications). Numerical questions on resolving power.

UNIT - 2
MICROBIAL NUTRITION AND GROWTH [10L]
The morphology and ultra-structure of Bacteria: Gram +ve, Gram –ve and Archaebacteria, Nutritional requirements: Basic nutrients, classification, culture media and types. Culturing of Bacteria: Types (pure culture techniques), Bacterial Growth: Growth curve, calculation of generation time, factors affecting growth, Measurement of growth: Direct and indirect methods, numerical questions in SPC, DMC and DCW.

UNIT - 3

MICROBIAL REPRODUCTION AND METABOLISM [9L]

Bacterial reproduction: Binary fission and Genetic recombination in bacteria, Fungi: Salient features, morphology, classification and reproduction. Viruses: general characteristics, classification and nomenclature, morphology and replication (of bacterial, plant and animal viruses in general).
Microbial Metabolism-overview of Metabolic pathways (Glycolysis, HMP, ED pathway, alcohol and acid fermentation-homo & heterolactic, mixed acid), Primary and secondary Metabolites-brief mention with examples and applications.

UNIT - 4

CONTROL OF MICROORGANISMS [7L]

Physical methods: Terminology, Microbial death curve, Physical methods: Heat, filtration, radiation, osmotic pressure, low temperature (instruments involved), Chemical methods: (Phenol & Phenolic compounds, Alcohols, Halogens, Dyes, Detergents, Aldehydes, Heavy metals, etc), Antibiotics and their mechanism of action.

UNIT - 5

APPLICATIONS OF MICROORGANISMS [5L]

Microbes in Agriculture: Recycling of Nutrients, Biofertilizers, Biopesticides, Aquatic Microbiology: microbial fauna of fresh and marine water, Microbes in Food industry: As food contaminants, Food processing, Microbes as food (Yeast and SCP).

PART B: PRACTICAL (2 Hr/week)

1. Laboratory rules, General instruments (Microscope, Autoclave, Hot air oven, Incubator, LAF) and other requirements in Microbiology laboratory.
2. Media preparation, plugging and sterilization. (NA/NB, PDA/PDB, MRBA, EMB agar, Blood agar, Mac Conkey agar).
3. Pure culture techniques (serial dilution, pour plate, spread plate and streak plate methods).
4. Isolation and characterization of Microbes from soil, Water and Air.
5. Examination of microorganisms from hand, nail, tooth scrapings and rotten fruits and vegetables.
6. Enumeration of microbes (Bacteria and Fungi) by DMC, SPC and Turbidometry.
7. Examination of living microbes by TWM technique, Hanging drop technique (Bacteria and Protozoa).
8. Staining techniques: Simple staining, Gram staining and endospore staining for Bacteria and Lacto phenol cotton blue staining for fungi.
9. Biochemical Tests (Starch hydrolysis, Gelatin liquefaction, MPN, Catalase and IMViC tests).
10. Measurement of growth and factors influencing growth of microbes (Determination by dry weight, effect of TDT and TDP, size determination by Micrometry).
11. Antibiotic susceptibility testing of bacteria.
12. Alcoholic and mixed acid fermentation.

TEXT BOOKS:

1. General Microbiology, Michael j Pelczar, Chan and Krieg, Tata McGraw Hill Pub
2. Industrial Microbiology, Prescott and Dunn, CBSPub. (4^{th} Ed.)

REFERENCE BOOKS:

1. General Microbiology, Stanier, John Ingraham and Mark Wheelis, Mac- Millan Pub.
2. Microbiology an Introduction, Tortora, Funke and Case. Pearson education.
3. Experiments in Microbiology, Plant pathology and Biotechnology,, K.R.Aneja(4th ed.)

e- books:

1. http://www.austincc.edu/rohde/noteref.htm
2. http://www.freebookcentre.net/medical_books_download/Medical-Microbiology.html
3. http://books.pakchem.net/microbiology-books.html

MOOCs:

1. https://www.mooc-list.com
2. https://www.mysliderule.com/topic/microbiology

Online courses: http://www.onlinecollegecourses.com

ASSESSMENT

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE OUTCOMES (COs):

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Understand the working principle and importance of various microscopes in analysis of physicochemical properties of microorganisms.
PO2 PO3	CO 2	Analyse and determine the growth, invitro culturing, physicochemical properties and controlling of microorganisms.
PO2 PO5	CO 3	Select and apply appropriate microorganisms and their value-added products in various applications
PO4	CO 4	Design, conduct experiments, analyse and interpret the data pertain to biochemical and metabolic potential of microorganisms.

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE

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Course Title	BASICS OF BIOMOLECULES													
Course Code	1	9	B	T	3	D	C	B	B	M	Credits	04	L – T – P	3 – 0 – 1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of chemistry, Mathematics and Basics of Biology.
COURSE DESCRIPTION: This course describes the structures of important biological molecules along with the basic concepts of organic and solution chemistry.
COURSE OBJECTIVES: This course is a foundation course needed to understand the concepts of Biochemistry & Bioenergetics, Bio analytical Techniques, Enzyme Technology, Molecular Biology, Genetic Engineering and Bioinformatics & Metabolic Engineering,

PART A: THEORY

UNIT - 1 BASIC CONCEPTS & STRUCTURE OF CARBOHYDRATES [9L]

Structure and properties of water, pH and buffers. Derivation and numerical on Henderson Hasselbach equation. Non-covalent interactions- hydrogen bonds, van der Waals forces, electrostatic and hydrophobic interactions.

Carbohydrates-Introduction, sources, classification into mono, oligo and polysaccharides, Classification of monosaccharides based on number of carbon atoms and functional groups, Isomerism: D & L and R and S nomenclature, Isomerism of carbohydrates, Fischer and Haworth formula, pyranose and furanose structures, anomers and epimers, chair and boat conformations, structure and function of simple sugars-mono and disaccharides, homo and hetero polysaccharides, sugar derivatives, glycoproteins.

UNIT - 2 STRUCTURE OF LIPIDS [4L]

Lipids- Introduction, sources, nomenclature, classification, properties and functions, Derived lipids-phospholipids, glycolipids, waxes, Steroids- structure and biological role .

UNIT – 3 STRUCTURE OF AMINO ACIDS AND PROTEINS [8L]

Introduction, classification, optical isomerism, chemical properties, acid-base properties polyionic nature, zwitter ions, pKa and pI, peptide bond formation and properties, biologically important peptides (oxytocin, vasopressin, bradykinin and glutathione), classification of proteins, levels of protein structure, determination of primary structure (sequencing strategies),

UNIT - 4 STRUCTURE AND CONFORMATION ANALYSIS OF PROTEINS [11L]

Conformational analysis and forces that determine proteins structures, geometries, potential energy calculations, phi, psi and omega angles, Ramachandran or steric contour diagram, potential energy calculations, allowed chi angles of side chains in proteins, hydrogen bonding, disulphide bonds, salt bridges, hydrophobic interactions, alpha helices, beta sheets, helix to coil transition, general features and thermodynamic aspects of protein folding and folding kinetics, protein-ligand interactions, Scatchard plot, co-operative interactions, allosteric effects, Hill constant, Relationship between the primary, secondary and tertiary structure of proteins, fibrous proteins (structure of collagen and keratin), Quaternary structures with Hemoglobin as an example.

UNIT - 5 STRUCTURE OF NUCLEIC ACIDS [7L]

General characteristics of nucleic acid structure, geometries, glycosidic bond, rotational isomers, ribose puckering, stabilizing ordered forms (A, B and Z forms), base pairing, base stacking, tertiary structure of nucleic acids, intra-molecular interactions in the double helix, thermodynamics of melting of DNA, interaction with small ions, tertiary structure of nucleic acids, Supercoiling, linking number, protein–DNA/RNA interactions.

PART B: PRACTICAL (2hrs/week)

1. Introduction to spectroscopic techniques
2. Preparation of buffers.
3. Qualitative tests for carbohydrates
4. Qualitative tests for lipids.
5. Qualitative tests for amino acids
6. Qualitative tests for proteins.
7. Tests for hemoglobin & derivatives
8. Determination of pKa of amino acids
9. Determination of iodine value of lipids.
10. Determination of saponification value of lipids.
11. Determination of Acid value of lipids.

TEXT BOOKS:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, W.H. Freeman and company (5th Ed.)
2. Biochemistry by Voet and Voet, Wiley New York
3. Lab manual by Faculty

REFERENCE BOOKS:

1. Principles of Biochemistry by Lubert Stryer Freeman (Int. Ed.)
2. Principles of Nucleic Acid Structure by Sanger, Springer Verlag
3. Principles of Protein Structure by G Schulz and R H Schrimer, Springer Verlag
4.An introduction to Practical Biochemistry by David T. Plummer, Tata Mc Graw Hill.(3rd Ed.))
5. Experimental Biochemistry by Beedu Sashidhar Rao and Vijay Deshpande, I.K. International Pvt.Ltd.

e-books:

1. https://archive.org/details/LehningersPrinciples of Biochemistry5e
2.http://www.tok.ro/toksite/downloads/Bioinformatika/Konyvek/biokemia,%20sejtbiologia%20%20konyvek/Stryer%20Biochemistry.pdf

MOOCs:

1. https://www.mooc-list.com/initiative/saylororg?static=true
2. https://www.mooc-list.com/course/principles-biochemistry-edx?static=true
3. http://nptel.ac.in/courses/102105034/

COURSE OUTCOMES (COs):

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Understand, define and explain concepts of structure and function of biomolecules
PO1	CO 2	Apply the concept of solution chemistry to compute the numericals related to preparation of solutions and buffers.
PO2	CO 3	Analyse the structural aspects of biomolecules and interpret the data.
PO2	CO 4	Design solutions to the challenges associated with dependence of functional aspects of biomolecules on the structure
PO4	CO5	Design and conduct experiments related to qualitative analysis of biomolecules and prepare solutions /buffers
PO4, PO9, PO10	Co 6 (open ended expts.)	Have the ability to individually search, read, and understand technical literature related to biomolecules and effectively design, conduct experiments & interpret data obtained based on the technical literature reviewed as well as be able to write a technical report

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.
Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE

Course Title	PROCESS PRINCIPLES AND CALCULATIONS													
Course Code	1	9	B	T	3	D	C	P	P	C	Credits	04	L – T – P	3 – 1 – 0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Engineering chemistry and mathematics.

COURSE DESCRIPTION: This subject puts emphasis on the basic engineering principles of bioprocess. It also highlights the modern application of biotechnological process and the role of bio process engineer in biotechnological industry.

COURSE OBJECTIVES: To enable the students to formulate and solve problems related to Energy balances of chemical reactions, Stoichiometric equations for microbial growth & product formation and Material balances in steady state unit operations

UNIT – 1 INTRODUCTION TO BIOPROCESS CALCULATIONS
[6L+2T]

Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases, concentration of solutions, Calculating dilutions: Concentrations by a factor of x, Preparing percent solutions, Diluting percent solutions, pH and pka calculations.

UNIT – 2 IDEAL GAS LAW and VAPOUR-PRESSURE [8L+2T]

IDEAL GAS LAW
Dalton's law and Amagat's Law, Relationship between partial pressure and mole fraction, Average molecular weight of gas mixture.

VAPOUR-PRESSURE

Vapour-Pressure concept, effect of temperature on vapour pressure, T-X-Y diagram, Raoult's law and Henry's law. humidity concepts. Humidity chart

UNIT – 3 MATERIALS BALANCE WITHOUT REACTION [8L+3T]

General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing, evaporation, Humidification & dehumidification. Elementary treatment of material balances involving bypass, Recycle and purge.

UNIT – 4 STEADY STATE MATERIAL BALANCE WITH REACTION [8L+3T]

Principles of Stoichiometry, Concept of limiting, excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, Fuels: Proximate and Ultimate analysis of coal, Combustion Calculations.

UNIT – 5 ENERGY BALANCE [9L+3T]

General steady state energy balance equation, Heat capacity. Enthalpy, Std. Heat of formation, Std. Heat of reaction and Std. Heat of combustion, Heat of solution. Heat of mixing, ΔH_c calculations, elevated temperatures, Stoichiometry of microbial growth & product formation, yield coefficient Concepts, Elemental material balance.

NOTE: Emphasis should be given on Biotechnological/Biochemical examples in all the units.

TEXT BOOKS:

1. Basic Principles and Calculations in Chemical Engineering by Himmelblau D. M. Ed 6. PHI Publishers (6th Ed.), 1997.
2. BioProcess Engineering, Basic concepts by Shuler & Kargi, PHI Publishers (2nd Ed.) 2002

REFERENCE BOOKS:

1. Chemical Process Principles Part – I by Hougen O. A., Waston K. M. and Ragatz R. A., Wiley, New York
2. Stoichiometry (SI Units) by Bhatt B. L. and Vora S. M. . Tata McGraw Hill (3rd Ed.), 1996.

e- books:

1.Chemical process and principles by Olaf a. Hougen and Kenneth M. Watson

MOOCs:

https://www.mooc-list.com

COURSE OUTCOMES (COs):

POs	COs	Description
-	CO 1	Comprehend the basic concepts of process calculations in biochemical engineering applications.
PO1	CO 2	Apply the knowledge of process calculations on material and energy balances on steady state unit operations involving with & without reactions.
PO2	CO 3	Analyze the stoichiometric equations for microbial growth & product formation for material balance calculations.
PO3	CO 4	Design the psychometric chart, study state unit operation material balance equations for with and without reactions.
PO12	CO 5	Deliver a seminar on the topic related to the course.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Course Title	BASICS OF COMPUTER APPLICATIONS													
Course Code	1	9	B	T	3	D	C	B	C	A	Credits	04	L – T – P	3 – 0 – 1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Basics of computer concepts

COURSE DESCRIPTION: This course imparts the knowledge about languages like SQL, PERL, Python, and MATLAB tools and their scope in biotechnology field. Students will be able to write Perl, Python scripts and MATLAB codes which are important in Bioinformatics and other biological science applications.

COURSE OBJECTIVES: The objective of the course is to make graduates comprehend the languages like SQL, PERL, Python, and MATLAB tools and prepare them to work individually and as a team in a multidisciplinary environment.

PART A: THEORY

UNIT – 1 Operating System concepts **[7 L]**

Introduction to O.S., types of O.S., O.S services, system calls, system components, system structures, virtual machines. Process Management - Process concept, process scheduling, co-operating processes, inter process communication, concept of threads and multithreading.

UNIX/Linux: Introduction to Linux, basic commands, working with the files, file attributes, pipes, wildcards, working with processes, working with basic editors (vi, emacs). Shell programming, basic decision making statements, basic regular expressions, string search applications using regular expressions.

UNIT – 2 BASICS OF DATABASES
[9 L]

DBMS: Database system-concepts and architecture. RDBMS: concepts, constraints, languages and design, Entity- Relationship model, Microsoft SQL server, introduction to SQL, basic commands, using SQL in MS Access, creating and modifying tables, joining tables, simple queries using SQL, inner join, outer joins, data sorting and filters.

UNIT – 3 PERL
[9 L]

An overview of Perl: Escape sequences, Numerical data types, strings in Perl, Operators, Perl statements: Introduction to statements, Types - Input/output statements, conditional statements, looping, and jumping statements. Lists: Introduction to lists and accessing list values. Arrays:

initializing array, adding elements to an array, accessing single and multiple elements from an array. Array manipulating functions (pop, push, shift, unshift, splice, sort). Hashes: Introduction to Hashes, creating a hash, working with hashes, adding, changing and accessing hash values. Regular expressions: Introduction to regular expressions, patterns, metacharacters, modifiers, grouping and alteration. Matching, substitution, translation and binding operators.

Representing Sequence Data, Store a DNA Sequence, Concatenating DNA Fragments, Transcription, Translation, Perl Documentation, Calculating the Reverse Complement in Perl, Reading Proteins in Files, Searching for motifs.

UNIT – 4 PYTHON [7 L]

Introduction, Syntax overview, Data types, variables, operators, decision making, loops, functions and modules, files I/O, exceptions, database access.

Python - Data Science: Data Cleansing, data processing [CSV and XLS], Data visualization: Box plots, heat maps and 3D charts.

UNIT – 5 MATLAB [7 L]

Introduction, Syntax overview, Data types, variables, operators, decision making, loops, arrays, matrix, functions, data I/O exceptions, plotting, graphics, Simulink.

Introduction to Bioinformatics Toolbox and Simbiology. Data Analysis, Statistics, probability distribution, hypothesis testing.

PART B: Practicals (2 hrs/week)

1. A Program to implement Data Definition language
2. A Program to implementation on DML, TCL and DRL
3. A Program to implement Nested Queries & Join Queries
4. Perl programs for Bioinformatics applications.
5. Python programming.
6. MATLAB programming.

TEXT BOOKS:

1. Operating system concept by Silberschatz, Peterhalvin and Greg Gauge, VI edition, John Wiley, 2003.
2. Linux: The complete reference by Richard Peterson, McGraw Hill, 1998.
3. Microsoft SQL Server 2008 For Dummies, Mike Chapple, 2009, John Wiley & Sons Publisher
4. Sandeep Nagar, Introduction to Python for Engineers and Scientists. Open Source Solutions for Numerical Computation-Apress (2018)
5. Rudra Pratap, Getting Started with MatLab A quick introduction for scientists and engineers, Oxford University Press
6. Beginning Perl for Bioinformatics, James Tisdall, Publisher: O'Reilly, First Edition October 2001

7. Perl cook book by O'Reilly & Associates, second edition, 2003.

REFERENCE BOOKS:

1. Learning Perl (III edition) by Tom Christiansen, Jon Orwant, Larry Wall, 2001.
2. SAMS teach SQL yourself in 10 minutes by Ben Forta, 3rd Edition
3. SQL Queries for more mortals: A hands on guide to data manipulation in SQL by Michael J. Hernandez and John L. Viescas (2000).
4. A First course in database systems by Jeffrey D. Ullman and Jennifer D. Widon. (2nd Ed.)

e-books:

1. Fangoh, Introduction to Python for Computational Science and Engineering, Open Source, available on github.
2. www.onlineprogrammingbooks.com/sql/
3. http://www.freebookcentre.net
4. http://www.getfreeebooks.com

MOOCs:

1. www.edx.org
2. www.w3schools.com
3. www.mooc-list.com

Course Outcomes

At the end of the course the student will be able to

PO	Course Outcomes(CO)	Description
	CO1	Comprehend the concept of operating system, DBMS and computer languages.
PO1	**CO2**	Apply the concept of SQL to create and constitute the PERL scripts for various applications.
PO2	**CO3**	Analyze the data using Python and MATLAB and deduce ER diagrams.
PO4, PO9	**CO4**	Conduct experiments to create and access the databases, execute the Perl scripts for various biological and allied applications and analyze the datasets using Python and MATLAB.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): a written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE have equal (50:50) weightages. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Course Title	UNIT OPERATIONS-1													
Course Code	1	9	B	T	3	D	C	U	O	1	Credits	03	L – T – P	3 – 0 – 0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of Engineering Physics and Mathematics

COURSE DESCRIPTION: This course provides students with the fundamental knowledge of momentum transfer and mechanical operations. This course gives the basic knowledge of fluid-flow phenomena, Kinematics of flow, Phenomena of flow past immersed bodies, and various aspects of transportation of fluids and metering of fluids. Basic concepts of dimensional analysis also included in this course. This course also emphasizes on different types of mechanical operations used in biochemical industries.

COURSE OBJECTIVES: The course objective is to make students capable of identifying the various types of fluids, their flow characteristics and their applications. This course will also enable students to understand the principle behind various mechanical operations like size reduction, filtration, sedimentation and mixing in upstream and downstream processes. This course will also train students to formulate, analyse and solve engineering problems involving fluid mechanics and mechanical operations.

PART A: THEORY

UNIT – 1 FLUID FLOW PHENOMENA [8L]

Significance of Dimensionless groups and constants, Dimensional analysis – Rayleigh's method, Buckingham's π method; Fluid definition and Classification (Newtonian and Non-Newtonian), Newton's law of viscosity, Pressure measurement using manometers, Hydrostatic equilibrium, Types of flow-laminar & turbulent, Flow in Boundary Layers, Reynolds experiment, Conceptual problems.

UNIT – 2 FLOW OF INCOMPRESSIBLE FLUIDS [8L]

Fluid flow – Continuity and Bernoulli equations, Flow through circular and non-circular conduits-Hagen Poiseuille equation, Pressure drop through packed bed - Ergun's equations, Conceptual problems.

UNIT – 3 FLOW MEASUREMENTS [9L]

Flow measurements - Orifice meter, Venturimeter, Rota meter, Performance & Characteristics of Pumps - Centrifugal & Reciprocating pumps, Energy calculations, Fans, Compressors and Blowers, Conceptual problems.

UNIT- 4 SOLID-SOLID SEPARATIONS [5L]

Size reduction – Laws governing size reduction and equipment, Conceptual problems; Sieve analysis – Types, Screen effectiveness & capacity, Cyclone separators and classifiers.

UNIT- 5 SOLID-LIQUID SEPARATIONS AND MIXING [9L]

Sedimentation & Settling - Batch & Continuous Sedimentation, Stoke's law, Terminal settling velocity. Kynch theory and Thickener design. Filtration - constant rate and constant pressure filtration, Filtration equipment, Fluidization -Characteristics of fluidized systems, flow through packed beds, Mixing – Types of mixers, power number, power consumption in mixing operation.

TEXT BOOKS:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill.
2. Introduction to chemical Engineering by Badger and Banchero. McGraw Hill.

REFERENCE BOOKS:

1. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann (5^{th} Ed.).
2. Principles of Unit Operations by Foust A.S. Et al, John Wiley & Sons Inc (2^{nd} Ed.).
3. Transfer Processes & Unit Operations by Geankoplis C.J., PHI Publishers (3^{rd} Ed.)

e-books:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill. (http://www.ualberta.ca/~seyedsha/Ebooks/Unit%20Operations%20Of%20Chemical%20Engineering,%205th%20Ed,%20McCabe%20And%20Smith.pdf)
2. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann
3. (http://traininghrd.nigc.ir/files/files/chemist%20book%20cd2/chemical%20eng/RICHARDSON,%20J.%20F.%20(2002)2/Coulson_Richardsons_Chemical_Engineering_Volume_2.pdf)

MOOCs:

1. https://www.edx.org/course/basics-transport-phenomena-delftx-tp101x#!
2. http://www.nptel.ac.in/syllabus/102106027/

COURSE OUTCOMES (COs):

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Comprehend the concepts of fluid dynamics, size reduction, filtration, sedimentation and mixing in upstream and downstream processes.
PO1	CO 2	Apply physical principles governing fluid flow types, characteristics, transport systems and mechanical operations in chemical and bioprocess industries.
PO2	CO 3	Identify, interpret and analyze and solve problems based on fluid flow and mechanical operations.
PO9, PO10	CO 4	Work individually in exploring applications of fluid mechanics and mechanical operations in biotechnology or bioprocess and communicate the findings of the literature as oral presentations and report submission.

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.
Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

DEPARTMENT OF BIOTECHNOLOGY

Course Title	SEMINAR													
Course Code	1	9	B	T	3	D	C	S	E	M	Credits	01	L – T – P	0 – 0– 1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of chemistry, physics Mathematics and Basics of Biology.

COURSE DESCRIPTION: A Students have to present a topic relevant to the file of Biotechnology

COURSE OBJECTIVES:, This course will help students be aware of the current trends in the field of Biotechnology

PO	(CO) COURSE OUTCOMES	Descriptor
PO1	CO 1	Survey literature pertaining to given topic
PO10	CO 2	Write effective report and present effectively by oral communication
PO9	CO 3	Ability to work individually or team.

FOURTH SEMESTER

Course Code	19HS3ICCPH/ 19HS4ICCPH	Course Name	Constitution of India, Professional Ethics and Human Rights
Credits	01	L-T-P	1-0-0

Course Objectives:

1. To educate students about the Supreme Law of the Land.
2. To value human dignity and to save the liberties of the people against discriminations.
3. To raise awareness and consciousness of the issues related to the profession and discuss the issue of liability of risks and safety at work place.

UNIT-1
Introduction to Indian Constitution [03 hours]

Historical Background of the Indian Constitution. Framing of the Indian constitution: Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India, Fundamental Rights and its limitations. Fundamental Duties and their significance. Directive Principles of State Policy: Importance and its relevance. Case Studies

UNIT -2
Union Executive and State Executive [02 hours]

The Union Executive – The President and The Vice President, The Prime Minister and The Council of Ministers. The Union Parliament – Lok Sabha & Rajya Sabha.
The Supreme Court of India.
State Executive – The Governors, The Chief Ministers and The Council of Ministers. The State Legislature – Legislative Assembly and Legislative Council. State High Courts.

UNIT -3 [02 hours]

Election Commission of India, Amendments and Emergency Provisions Election Commission of India – Powers & Functions – Electoral Process in India. Methods of Constitutional Amendments and their Limitations.
Important Constitutional Amendments – 42nd, 44th, 61st,74th, 76th, 77th, 86th and 91st. Emergency Provisions. Case Studies.

UNIT-4 [02 hours]

Special Constitutional Provisions/ Human Rights. Special Constitutional Provisions for Schedule Castes, Schedule Tribes & Other Backward Classes. Women & Children. Case Studies. Human Rights/values – Meaning and Definitions, Legislative Specific Themes in Human Rights and Functions/ Roles of National Human Rights Commission of India. Human Rights (Amendment Act)2006.

UNIT-5 **[03 hours]**

Scope and Aims of Engineering Ethics, Responsibilities of Engineers and impediments to responsibilities. Honesty, Integrity and Reliability; Risks – Safety and Liability in Engineering. Case Studies.

Course Outcomes:
Students will:
1: Understand and explain the significance of Indian Constitution as the Fundamental Law of the Land.
2: Analyse the concepts and ideas of Human Rights.
3: Apply the practice of ethical responsibilities and duties to protect the welfare and safety of the public.

At the end of the course, the student will have the ability to

CO1	Understand and explain the significance of Indian Constitution as the Fundamental Law of the Land.	**Remember**
CO2	Analyse the concepts and ideas of Human Rights.	**Analyse**
CO3	Apply the practice of ethical responsibilities and duties to protect the welfare and safety of the public.	**Application**

Text Books:

1. "An Introduction to Constitution of India and Professional Ethics" by Merunandan K.B. and B.R. Venkatesh, Meragu Publications, 3rd edition, 2011.
2. "Constitution of India & Professional Ethics & Human Rights" by Phaneesh K. R., Sudha Publications, 10th edition, 2016.

Reference Books:

1. "V.N. Shukla's Constitution of India" by Prof (Dr.) Mahendra Pal Singh (Revised), Eastern Book Company, Edition: 13th Edition, 2017, Reprint 2019.
2. "Ethics in Engineering" by Martin, W. Mike.,Schinzinger, Roland., McGraw-Hill Education; 4^{th} edition (February 6, 2004) .

E-Book:

1. https://books.google.co.in/books/about/Constitution_of_India_and_Professional_E.html?id=VcvuVt-d88QC
   Constitution of India and Professional Ethics, by G.B. Reddy and Mohd Suhaib, I.K. International Publishing House Pvt. Ltd., 2006.
2. http://www.scribd.com/doc/82372282/Indian-Constitution-M-Raja-Ram-2009#scribd
   Indian Constitution, by M. Raja Ram, New Age International Pvt. Limited, 2009.

Course Outcomes and Programme outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												

Course Title	Biostatistics and Probability	Course Code	19MA4BSBSP
Credits	04	L – T – P	3 – 1 – 0
Contact hours	48 hours (36L+12T)		

Prerequisites: Basic concepts of Statistics and Probability, addition theorem, conditional probability, Bayes' theorem, discrete random variable, Binomial distribution. Basic concepts of statistics. Matrices.

Course Objectives: Student will get acquainted with the procedure of collecting, designing, analysing and drawing inference about the data.

UNIT-1

STATISTICS & PROBABILITY [8L+3T]

Curve fitting – Principle of least squares, fitting a straight line, fitting of a parabola, fitting of exponential curve of the form $y = ab^x$. Correlation and regression.
Discrete distribution: Poisson distribution, Continuous distributions: Normal and Gamma distributions.

UNIT-2

JOINT PROBABILTY AND MARKOV CHAIN [6L+2T]

Joint Probability Distributions:

Discrete random variables, Mathematical expectations, Covariance and Correlation.

Markov Chain:

Markov Chain, Probability vectors, stochastic matrices, fixed point vector, regular stochastic matrices. Higher transition probabilities, stationary distribution of regular Markov chain.

UNIT-3

DESIGN OF EXPERIMENTS [7L+2T]

Principles of experimental design – Randomisation, Replication, Local Control.
Randomised block design, Completely Randomised block design, Latin Square Design, Factorial Experiments, Plackett Burman Design.

UNIT-4

STATISTICAL INFERENCE – I [9L]

Introduction, estimation – point, interval; procedure for testing of hypothesis, level of significance, construction of confidence interval.

[Large sample] Test of significance for single mean, difference between two means, single proportion, difference between two proportions, and difference of two Standard deviations for the biological data sets.

UNIT-5

STATISTICAL INFERENCE – II [11L]

[Small sample] Test of significance for single mean, difference between two means, paired t-test, ratio of variances (F- distribution), Chi -Square distribution-goodness of fit, independence of attributes. Analysis of variance (one-way and two-way classifications). Non parametric test – Kruskal – Wallis One Way Analysis of Variance by Ranks for the biological data sets.

On Completion of the course, student will have the ability to:

Course Code	CO #	COURSE OUTCOME (CO)	PO
19MA4BSBSP	CO 1	Appreciate the use of Statistical methods to Analyze and interpret the data from real world examples.	1,2,9,10
	CO 2	Apply the basic principles of probability and Probability distributions to the problems in Engineering.	1,2
	CO 3	Apply the concepts of Markov chain to the field of genetics.	1,2
	CO 4	Demonstrate an understanding of sampling distributions and principles of experimental design.	1,2

Text Books:

1. Fundamentals of Biostatistics, Khirfan A. Khan, Atiya Khanum, 3rd edition, 2012, Ukaaz Publications.
2. An Introduction to Biostatistics, P. S. S. Sundar Rao and J. Richard, 4th edition, 2006, Prentice Hall of India.

Reference Books:

1. Biostatistics: A foundation for Analysis in the Health sciences, Wayne W. Daneil, 10th edition, 2013, John Wiley & Sons.
2. Biostatistics, P. N. Arora, P. K. Malhan, 2nd edition, 2013, Himalaya Publishing House.

E books and online course materials:

1. https://www.coursera.org/learn/basic-statistics
2. https://www.coursera.org/learn/probability-intro
3. https://www.classcentral.com/course/udacity-intro-to-statistics-361
4. http://wiki.stat.ucla.edu/socr/index.php/Probability_and_statistics_EBook

Online Courses and Video Lectures:

1. http://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring- 2014/
2. http://nptel.ac.in/courses/*111105041/1* NPTEL >> Mathematics >> Probability and Statistics
3. https:// www.khanacademy.org/Math
4. https:// www.class-central.com/subject/math (MOOCS)

Question Paper Pattern:

1. Five full questions to be answered.
2. To set one question in Units 2, 3, 4 and two questions from Unit 1 and Unit 5.

Course Title	UNIT OPERATIONS-2													
Course Code	1	9	B	T	4	D	C	U	O	2	Credits	04	L – T – P	3 – 0– 1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of Process Engineering Thermodynamics and Process Principles and Calculations.

COURSE DESCRIPTION: This course provides students with the fundamental knowledge of heat and mass transfer. The course also includes heat and mass transfer problems and description of phase diagrams and experimental equipment. Practical part includes experiments on mechanical operations, momentum transfer, heat transfer in heat exchangers and mass transfer operations.

COURSE OBJECTIVES: The course objective is to provide students with the fundamental knowledge needed to successfully practice the profession of biological engineering using the knowledge of heat and mass transfer. It trains students to design, test, and analyze systems and processes that involve transport phenomena. The course also enables students to formulate and solve heat and mass transfer problems and to use experimental equipment. It will also help students develop their ability to apply knowledge of mathematics, science and engineering to conduct experiments and interpret data. Students will learn to identify, formulate and solve engineering problems.

PART A: THEORY

UNIT – 1 CONDUCTIVE & CONVECTIVE HEAT TRANSFER [9 L]

Modes of heat transfer, Conduction - Steady state heat conduction through unilayer and multilayer walls, critical thickness of insulation, Overall & Individual heat transfer co-efficient, LMTD, Forced & natural convection, Basic concepts in unsteady state heat conduction, Heat Transfer equipment - Double pipe heat exchanger, Shell and Tube heat exchanger, Conceptual problems.

UNIT – 2 CONDENSATION AND EVAPORATION [7 L]

Condensation - Film wise & drop wise condensation, Evaporation principle, Evaporators - Horizontal tube evaporator, long tube vertical evaporator, Forced circulation evaporators, Single and multiple effect evaporator, Enthalpy balances and Economy of evaporator, Conceptual problems.

UNIT – 3 BASICS OF MASS TRANSFER [8 L]

Mass transfer Operations, Diffusion – Types, Steady state diffusion:- Fick’s I law, equimolar counter current diffusion, Measurement of diffusivity, Mass transfer coefficients, Conceptual problems, Basic concepts in unsteady state diffusion, Fick’s II law, Theories of mass transfer across phase boundaries – two film theory and penetration theory, Analogy between heat and mass transfer using dimensionless numbers.

UNIT – 4 MASS TRANSFER OPERATION – I [10 L]

Distillation - Methods of distillation, Distillation of binary mixtures – Raoults law, McCabe Thiele method, Conceptual problems; Basic concepts in Extraction – Leaching operation - Principle, Mass transfer in leaching operations, Liquid-Liquid extraction - Principle, ternary equilibrium diagram, equilibrium calculations, Aqueous two phase separations.

UNIT – 5 MASS TRANSFER OPERATION – II [5 L]

Basic concepts in Adsorption - Nature of adsorbents, Adsorption Isotherms; Ion exchange - Principle; Drying - Principle of drying, drying rate curve; Crystallization – Principle, stages in crystallization and methods of super saturation.

PART B :PRACTICALS (2HRS/WEEK)

The experiments should cover any 12 of the following topics.

A) Momentum Transfer

1. Friction in circular pipes
2. Flow rate measurement using venturi / orifice meters (incompressible fluid)
3. Characteristics of centrifugal Pumps

B) Mechanical Operations

1. Batch sedimentation
2. Leaf filter
3. Screen effectiveness
4. Drop weight crusher

C) Heat Transfer

1. Unsteady State heat conduction
2. Vertical/Horizontal condenser
3. Heat transfer in Double Pipe Heat exchanger

D) Mass Transfer

1. Distillation – Simple (Differential) distillation
2. Packed column distillation
3. Diffusion of organic vapors in Air
4. Liquid-Liquid extraction

TEXT BOOKS:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill.
2. Introduction to chemical Engineering by Badger and Banchero. McGraw Hill.

REFERENCE BOOKS:

1. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann (5^{th} Ed.).
2. Principles of Unit Operations by Foust A.S. Et al, John Wiley & Sons Inc (2^{nd} Ed.).
3. Transfer Processes & Unit Operations by Geankoplis C.J., PHI Publishers (3^{rd} Ed.)
4. Biological and Bioenvironmental Systems Heat and Mass Transfer by Dutta A.K., Technology & Engineering (2002).

e-books:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill.
2. http://www.ualberta.ca/~seyedsha/Ebooks/Unit%20Operations%20Of%20Chemical%20Engineering,%205th%20Ed,%20McCabe%20And%20Smith.pdf
3. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0CEcQFjAH&url=https%3A%2F%2Fornithopter.googlecode.com%2Ffiles%2FCoulson__Richardsons_Chemical_.pdf&ei=p0iJVfLFE4XiuQTA6aTwDg&usg=AFQjCNFgBbve1dez_wkIdeYqMUfMKuuxCQ&bvm=bv.96339352,d.c2E

MOOCs:

1. https://www.edx.org/course/basics-transport-phenomena-delftx-tp101x#!
2. http://ocw.mit.edu/courses/chemical-engineering/10-302-transport-processes-fall-2004/index.htm
3. http://www.nptel.ac.in/syllabus/102106027/

COURSE OUTCOMES (Cos):

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Comprehend the concepts of modes of heat transfer, heat exchangers, evaporators, insulation, diffusion and separation processes.
PO1	CO 2	Apply physical laws governing heat transfer and mass transfer in bioprocess operations.
PO2	CO 3	Identify, interpret and analyze and solve problems based on steady state heat and mass transfer phenomena.
PO4	CO 4	Conduct experiments on mechanical operations, momentum transfer, heat transfer and mass transfer operations.
PO9, PO10	CO 5	Work individually to Identify real life problems associated with unit operations in biotechnology or bioprocess, search for solutions, and communicate the findings of the literature study and solution proposed, as oral presentations and report submission.

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.
Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	CELL AND MOLECULAR BIOLOGY												
COURSE CODE	1	9	B	T	4	D	C	C	M	B	Credits	04	L-T-P	3-0-1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of basics of cell biology and genetics

COURSE DESCRIPTION: The Molecular biology course focuses on the molecular aspects of the cell and its molecular components especially DNA, RNA and protein. The course deals with the application of the cell structure and its function to the molecular processes. The course relate to all cellular processes involving the genetic material and its output, viz., replication, transcription, translation, DNA repair and Recombination as well as their regulation.

COURSE OBJECTIVES: The graduates having basic knowledge of cell structure, functions and genetics can understand the concepts of molecular process and its regulation and gene and global level. The course thus would provide a background appropriate for applying the knowledge in applied biotechnology such as genetic engineering, genomics, Bioinformatics, Pharmaceutical Biotechnology, diagnostics, and therapeutics.

PART A : THEORY

UNIT - 1 INTRODUCTION TO CELL & REPLICATION OF DNA

[12 L]

Structural differences between pro and eukaryotic cell, Nucleus, Chromosome, genome and their packaging in Prokaryotic and eukaryotic cell, Nucleolus and transcription, Chromatin and its relation with transcription regulation, Role of ER in translation and protein maturation, Golgi and its role in PTM, Plasma membrane and signal transduction, cytoskeletal elements and their role in molecular processes . Information flow in biological systems: central dogma and updated central dogma (Retroviral & HIV replication involving reverse transcriptase as a case study). DNA as the genetic material, cell cycle and linking cell cycle with DNA replication and regulation. Experiments related to DNA replication, Replication of DNA in pro and eukaryotes: Basic mechanism including initiation, elongation and termination in Bacteria and Yeast, Inhibitors of replication.

UNIT 2 DNA DAMAGE, REPAIR & RECOMBINATION [6 L]

DNA Damage and its role in carcinogenesis, Mutations, types, mutagens. DNA Repair, various types. Genetic recombination in eukaryotes and prokaryotes, Homologous recombination, Holliday junctions, Site-specific & illegitmate recombination. DNA transposons, retrotransposons, retroviral integration.

UNIT 3 PRO & EUKARYOTIC TRANSCRIPTION [9 L]

Genes structure and their function, RNA polymerases (prokaryotes & eukaryotes), mechanism of transcription in prokaryotes and eukaryotes, general and basal transcription factors, promoters, enhancers, Experiments as gel shift, promoter deletion ,transcription run-on assay, linker scanning promoter analysis. RNA Processing: exons & introns, splicing, spliceosomes, snRNPs, self-splicing introns, capping, polyadenylation. RNA editing, trans-splicing, RNA interference, siRNAs, miRNAs, other ncRNA, transcription inhibitors.

UNIT 4 PRO & EUKARYOTIC TRANSLATION [7 L]

Ribosome structure & function, genetic code, Mechanism of translation, activation of amino acid initiation, elongation and termination of protein synthesis. Experiments related to interactions between RNAP and the ribosome through *in vitro* transcription-coupled-to-translation systems. Post and Co-translational modifications, folding and maturation, translocation, Protein Misfolding disorders, inhibitors of translation.

UNIT 5 GENE EXPRESSION AND REGULATION [5 L]

Gene regulation in mono and polycistronic genes, Operon models: gal, lac, trp; positive versus negative regulation, Chromatin structure & regulation, histone modifiers, coactivators & corepressors, transcriptional control.

PART B: CELL & MOLECULAR BIOLOGY PRACTICALS [2 hrs/Week]

1. Study of mitosis from onion root tips
2. Study of meiosis from onion flower buds.
3. Organelle isolation (mitochondria, chloroplast).
4. Isolation and fusion of protoplast.
5. Differential staining of blood cells.
6. Isolation, characterization, Quantification of genomic DNA from bacteria.
7. Isolation, characterization, Quantification of genomic DNA from plant/ animal cells.
8. Agarose gel electrophoresis for size determination.
9. DNA replication through cell doubling.
10. Transcription: Banding of polytene chromosomes.

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Understand the structure and function of bio molecules and their interactions
PO1	CO 2	Compare & contrast molecular processes in bacteria & eukaryotes.
PO2	CO 3	Interpret the results of molecular experiments to current and relate to the current understanding about complex process.
PO6	CO 4	Apply the knowledge of molecular mechanisms to human disease states with underlying dysfunctions
PO4	CO5	Use research based knowledge & methods to conduct experiments, analyze & interpret data related to cell & its processes.

PRIMARY REFERENCES

1. Molecular Biology of the Cell, Bruce Alberts Garland Science Pub.
2. Cell and Molecular Biology by Gerald Karp, John Wiley & Sons.
3. Genes VIII/IX/X/XII by Lewin

SECONDARY REFERENCES

1. Cell and Molecular Biology by Lodish, Freeman pub.
2. Molecular Cell Biology by Darnell and Baltimore.

e- books

1. Molecular Biology of the Cell, Bruce Alberts Garland Science Pub.

   http://bit.ly/MolBioCell5thPDFFree

2. Molecular Biology by David Freifelder

   https://openlibrary.org/authors/OL773152A/David_Freifelder

MOOCs

1. http://www.nptel.ac.in/courses/102103012/
2. https://www.mooc-list.com/tags/biotechnology
3. http://ocw.mit.edu/courses/biology/

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.
Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE

COURSE TITLE	PROCESS ENGINEERING THERMODYNAMICS													
COURSE CODE	1	9	B	T	4	D	C	P	E	T	Credits	04	L-T-P	3-1-0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of Engineering Physics, Chemistry and Mathematics.

COURSE DESCRIPTION: This course includes basic thermodynamic principles and related conceptual engineering problems. This course presents basic definition and development of laws of thermodynamics. The course also focusses on PVT behavior of pure fluids and properties of fluids. It will also have description of basic concepts of vapor/liquid equilibrium, chemical equilibrium, phase equilibria, bioenergetics and heterogeneous reaction equilibria.

COURSE OBJECTIVES: The objective of the course is to prepare the students to understand and apply the various concepts in thermodynamics in biochemical engineering processes.

UNIT – 1 BASIC CONCEPTS AND LAWS OF THERMODYNAMICS [8L+3T]

System, Surroundings & Processes, Open & Closed systems, State properties, Intensive & Extensive Properties, State & Path functions, Equilibrium state & Phase Rule, Zeroth Law of Thermodynamics, Reversible & Irreversible processes, First Law of Thermodynamics, Heat Capacity, Heat reservoirs & Heat Engines, Second Law of thermodynamics, Concept of entropy, Carnot Principle, Calculation of entropy changes, Clausius inequality, Entropy & irreversibility, Third law of Thermodynamics.

UNIT – 2 PVT BEHAVIOUR AND COMPRESSIBILITY CHARTS [8L+2T]

PVT Behaviour of pure fluids, Equations of state & Ideal gas law, Processes involving ideal gas law: Constant volume, Constant pressure, Constant temperature, Adiabatic & Polytrophic processes, Equations of state for real gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, Virial equation, Principles of corresponding states, Generalized compressibility charts, Heat effects accompanying chemical reactions, Standard heat of reaction, formation, combustion, Hess's law of constant heat summation, Effect of temperature on heat of reaction.

UNIT – 3 PROPERTIES OF PURE FLUIDS AND PROPERTIES OF SOLUTIONS [8L+3T]

Work function, Gibbs free energy, Relationships among thermodynamic properties: Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy & heat capacity relations, Modified equations for internal energy (U) & enthalpy (H), Effect of temperature on U, H & entropy (S), relationships between Cp and Cv, Gibbs-Helmholtz equation, Fugacity, fugacity coefficient, effect of temperature & pressure on fugacity, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: Effect of temperature and pressure on activity, Partial molar properties, chemical potential, fugacity in

solutions, Henry's law and dilute solutions, Activity in solutions, activity coefficients, Gibbs-Duhem equation, Property changes of mixing, Excess properties.

UNIT – 4 PHASE EQUILIBRIA [7L+3T]

Criteria of phase equilibria, Criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, Consistency test for VLE data, Calculation of activity coefficients using Gibbs- Duhem equation, Liquid-Liquid equilibrium.

UNIT – 5 BIOCHEMICAL ENERGETICS [8L+2T]

Reaction stoichiometry, Criteria of biochemical reaction equilibrium, Equilibrium constant & standard free energy change, Effect of temperature, Pressure on equilibrium constants & Other factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous bioreaction equilibria, Phase rule for reacting systems. Stochiometric and energetic analysis of cell growth and product formation-elemental balances, degree of reduction concepts-available –electron balance, yield coefficients, oxygen consumption and heat evolution in aerobic cultures, thermodynamics efficiency of growth.

Bibliography

TEXT BOOKS:

1. Introduction to Chemical Engineering Thermodynamics by Smith J. M., Van Ness H. C. McGraw Hill (6th Ed.), 2003.

2. A Textbook of Chemical Engineering Thermodynamics by Narayanan K. V., Ed 1. PHI publishers (1st Ed.), 2001.

REFERENCE BOOKS:

1. Biochemical Calculations by Segel I. H., John Wiley & Sons Inc. (2nd Ed.), 1976.
2. Chemical Engineering Thermodynamics by Rao Y. V. C., New Age International.
3. Engineering Thermodynamics by Jones J. B., Hawkins. , John Wiley & Sons Inc.

e-books:

1.Engineering thermodynamics by P K Nag.
2.Engineering thermodynamics by Tarik Al Shemmeri.

MOOCs:

1.www. nptel. ac. in -biotechnology-thermodynamics
2.www.ocw.mit.edu-thermodynamics and kinetics.

COURSE OUTCOMES (COs):

POs	COs	Description
-	CO-1	Comprehend the concepts of process engineering thermodynamics.
PO-1	CO-2	Apply the laws of thermodynamics in physical, chemical and biological systems
PO-2	CO-3	Analyze the problems related to phase and reaction equilibria.
PO-3	CO-4	Design solution for problems related to thermodynamics for given chemical or bio process.
PO-5	CO-5	Review literature related to biochemical thermodynamics and analyze the problems individually.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Course Title	BIOCHEMISTRY & BIOENERGETICS													
Course Code	1	9	B	T	4	D	C	B	A	B	Credits	04	L – T – P	3 –0– 1
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)		

COURSE PRE-REQUISITES: Knowledge of organic chemistry and Basics of Biomolecules

COURSE DESCRIPTION: This course describes the major metabolic pathways and their bioenergetics.

COURSE OBJECTIVES: This course is a foundation course needed to understand the concepts of Metabolic Engineering, Enzyme Technology, Structural Biology and Bioinformatics.

PART A: THEORY

UNIT – 1 PRINCIPLES OF BIOENERGETICS [6L]

High energy compounds, Structure and properties of ATP, Thermodynamic concepts, Free energy change and equilibrium constant, Coupling reactions, Free energy and oxidation–reduction potential, Bio-energetic interconversions and associated thermodynamic constraints, Simple numerical.

UNIT – 2 CARBOHYDRATE METABOLISM [9L]

Introduction, Glycolysis: pathway, regulation and bioenergetics, Gluconeogenesis: pathway regulation and bioenergetics, Glycogen metabolism: degradation, synthesis, regulation and bioenergetics, Hexose interconversions, TCA cycle: pathway, regulation and bioenergetics, Amphibolic and Anaplerotic reactions, HMP pathway, Glyoxylate pathway, Structure and functions of electron carriers of ETC, Respiration and ATP formation in mitochondria, Electron transport chain, Oxidative phosphorylation, Energetics of Electron transport chain, Ion-electrochemical potential difference calculations, Malate-Aspartate shuttle system.

UNIT – 3 PHOTOSYNTHESIS [7L]

Introduction, Bacterial photosynthesis, Chloroplast/thylakoid structure, Photosynthetic apparatus, Photosynthetic reaction centre, Hill reaction, Light reaction, Cyclic and non-cyclic photophosphorylation, CO2 assimilation reaction, C4and CAM pathways, Photorespiration.

UNIT – 4 LIPID METABOLISM [8L]

Digestion, mobilization and transport of fats, Oxidation of saturated fatty acid & its Energetics, Formation of ketone bodies and their oxidation, Biosynthesis of fatty acid: fatty acid synthase complex, biosynthesis of palmitate and its energetics, Biosynthesis of phospholipids and their Energetics, Biosynthesis of cholesterol and its regulation.

UNIT – 5 NITROGEN METABOLISM [9L]

Overview of amino acid catabolism in mammals: transamination (mechanism of transamination involving PLP to be included), oxidative deamination, Nitrogen excretion, Urea cycle and its energetics, Biosynthesis of amino acids of oxaloacetate family.

Biosynthesis of nucleotides: de novo purine nucleotide synthesis (AMP and GMP), de novo pyrimidine nucleotide synthesis (UTP, CTP and dTTP), Regulation of biosynthesis of purine and pyrimidine nucleotides, Recycling of purine and pyrimidine nucleotides by salvage pathway, Catabolism of purine and pyrimidine nucleotides.

TEXT BOOKS:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, W.H. Freeman and company (5th Ed.)

2. Principles of Biochemistry by Lubert Stryer (Freeman Int. Edition)

3. Lab manual by Faculty

REFERENCE BOOKS:

1. Biochemistry by Voet and Voet, Wiley New York

2. Biochemistry by Garett and Grisham, Thompson Learning

3. Bioenergetics by David.G.Nicolls and Styart J. Ferquson, Academic Press, Elsevier

4. An introduction to Practical Biochemistry by David T. Plummer, Tata Mc Graw Hill (3rd Ed.)

5. Experimental Biochemistry by Beedu Sashidhar Rao and Vijay Deshpande, I.K. International Pvt. Ltd.

e-books

1. https://books.google.co.in/books/about/Bioenergetics.html?id=0_9EWX1fg8wC&redir_esc=y

2. https://archive.org/details/LehningersPrinciplesOfBiochemistry5e

MOOCs

1. https://www.mooc-list.com/course/principles-biochemistry-edx?static=true

2. http://nptel.ac.in/syllabus/syllabus.php?subjectId=102101002

PART B: practicals (2hrs/week)

1. Estimation of blood sugar by O-toluidine method.
2. Estimation of blood sugar by Hegde and Johnson method
3. Estimation of inorganic phosphate by Fiske-Subbarow method.
4. Estimation of amino acid by ninhydrin method.
5. Estimation of urea by diacetyl monooxime method.
6. Estimation of protein by Bradford method
7. Estimation of cholesterol by Zak and Henly's method.
8. Estimation of serum alkaline phosphatases
9. Estimation of serum transaminases
10. Estimation of serum creatinine
11. Protein characterization by fluorescence spectroscopy

COURSE OUTCOMES (COs):

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Understand the basic aspects of metabolic pathways of proteins, nucleic acids ,lipids, and carbohydrates
PO1	CO 2	Apply the principles of thermodynamics to compute the bioenergetics of metabolic pathways in living systems
PO2	CO 3	Analyze the role of key metabolic reactions and intermediates in the regulation of pathways and their mode of regulation
PO2	CO 4	Analyze the changes in concentration of key intermediary metabolites under different physiological conditions
PO4	CO5	Design, conduct experiments related to quantitative analysis of biomolecules and interpret data
PO4, PO9, PO10	CO6 (open ended expts.)	Engage in independent learning and work effectively as an individual to carry out literature search effectively, design, conduct experiments & interpret data and write a technical report.

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.
Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE

Course Title	INDUSTRY HANDLED COURSE													
Course Code	1	9	B	T	4	D	C	I	H	C	Credits	01	L – T – P	1 – 0 – 0
CIE	100 marks /50 Marks										SEE	50marks		

COURSE PRE-REQUISITES: Knowledge of chemistry, Mathematics and Basics of Biology.
COURSE DESCRIPTION: This course will be handled by experts from industries.
COURSE OBJECTIVES:, This course will help students learn the safety measures and hazard handling protocols, SOPs followed in industries.

Industrial Safety and Hazards
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. Case studies.

Course outcomes:

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	Understand the importance of safety and hazard evaluation and management in industries / environment Health& safety.
PO6	CO 2	Apply reasoning to access safety issues and suggest appropriate measures in industries.

Course Title	SEMINAR													
Course Code	1	9	B	T	4	D	C	S	E	M	Credits	04	L – T – P	0 – 0– 2
CIE	100 marks (50% weightage)										SEE		100 marks (50% weightage)	

COURSE PRE-REQUISITES: Knowledge of chemistry, physics Mathematics and Basics of Biology.
COURSE DESCRIPTION: Student need to present a topic relevant to the field of Biotechnology

COURSE OBJECTIVES: This course will help students be aware of the current trends in the field of Biotechnology

PO	(CO) COURSE OUTCOMES	Descriptor
PO1	CO 1	Survey literature pertaining to given topic
PO10	CO 2	Write effective report and present effectively by oral communication
PO9	CO 3	Ability to work individually or team.

Course Title	PERSONALITY DEVELOPMENT AND COMMUNICATION SKILLS													
Course Code	1	9	B	T	4	N	C	P	D	C	Credits	00	L – T – P	0 – 0 – 0
CIE	100 marks /50 Marks										SEE	NA		

Pre requisite: Basic communication and writing skills in English.

Course Objectives: This course enables students to develop interpersonal, communication, team building and management skills.

UNIT-1

Personality Development: Meaning, need, Introduction to Personality, Definition and Determinants-Personality Traits-Ways of developing positive personality traits, self-awareness, Habits-Ways of forming good habits. Self-discipline.

Attitude: Definition, Components, Determinants and Types – Building and Maintaining PMA (Positive) Mental Attitude).

UNIT-2

Self Esteem: Introduction, Definition and Types – Faces of low self-esteem – Steps to improve low self-esteem.

Self-Motivation: Definition-Ways of Building self-motivation.

Leadership: Key Elements of Leadership-Types of Leaders, Trait of an effective leader.

Teams: Difference between a team and Group-Stages of Team development (The Five stage Model), Team effectiveness.

UNIT-3

Time Management: Benefits-Effective-Time Management techniques.

Stress Management: Introduction – Understanding Stress-Stressors- Strategies to deal with Stress.

UNIT – 4

Communication: Introduction, Meaning, Types, Purpose and Definition-Communication Process (The Linear Concept, Shannon-Weaver Model) 7 Cs of Communication-Barriers to Effective Communication

Oral Communication: Principles of successful oral communication,

Written Communication: Purpose, principles of effective writing, 3x3 writing process Non-Verbal Communication and Meta Communication

UNIT – 5

APPLICATION OF ORAL AND WRITTEN COMMUNICATION

Negotiation Skills, Assertiveness, Presentation Skills, Impact of Technological Advancement on Business Communication

WORKPLACE COMMUNICATION:

Business Letters: Types, Layouts, Structure.

Reports: Purpose, Types, Structures.

EMMPLOYMENT COMMUNICATION: Resume and Cover Letter, Group Discussions and Employment Interviews

REFERENCES

Test Books:

1. Personality Development: Harold R.Wallace and Ann Masters Cengage Learning.
2. Personality Development and Soft Skills: BaruMitra, oup India.
3. Business Communication: P.D. Chaturvedi and Mukesh Chaturvedi, Pearson Education.
4. Business Communication: Lesikar, Flatley, Rentz and Pande, TMH.

Reference Books:

1. The Skills of Communicating: Bill Scott, Jaico Books.
2. Developing Effective People: Lesley Morrissey, Jaico Books.

e-books:

1. Personality Development and Soft Skills: BarunMitra, OUP India.
2. a. Effective Communication Skills By MTD Training 1
   b. Effective Communication Skills by MTD Training 2

MOOCs:

1. Communication in the 21st Century Workplace-offered by Coursera
2. Communication strategically-offered by edX

Semester-V

Course Type	Course Code	Course Title	Credits			Total Credits	Contact hours/ week	Marks		
			L	T	P			CIE	SEE	Total
HS-3	19BT5HSEM	Entrepreneurship(MOOC/NPTEL/SWAYAM)	2	0	0	2	2	50	50	100
PC-11	19BT5DCREN	Reaction Engineering	2	1	0	3	4	50	50	100
PC-12	19BT5DCGEN	Genetic Engineering	3	0	1	4	4	50	50	100
PC-13	19BT5DCBPT	Bioprocess technology	2	1	1	4	5	50	50	100
PC-14	19BT5DCBAT	Bioanalytical Techniques	3	0	1	4	4	50	50	100
PE-1	19BT5DEPE-1	Professional elective 1	3	0	0	3	3	50	50	100
PE-2	19BT5DEPE-2	Professional elective 2	3	0	0	3	3	50	50	100
PW-1	19BT5DCPRW	PW 1 Multidisciplinary Project (Among the clusters)	0	0	2	2	2	50	50	100
TOTAL			**18**	**2**	**5**	**25**	**27**	**400**	**400**	**800**

PE-1	19BT5DE1IMM	Immunotechnology	3	0	0	3	50	50	100
	19BT5DE1TPN	Transport Phenomena	3	0	0	3	50	50	100
	19BT5DE1MEB	Membrane Biology	3	0	0	3	50	50	100

PE-2	19BT5DE2AGT	Agricultural BT	3	0	0	3	50	50	100
	19BT5DE2RPG	R-Programming	3	0	0	3	50	50	100
	19BT5DE2BBI	Biosensors & Bio instrumentation	3	0	0	3	50	50	100

Semester-VI

Course Type	Course Code	Course Title	Credits			Total Credits	Contact hours/ week	Marks		
			L	T	P			CIE	SEE	Total
HS-4	19BT6HSPMF	Project Management and Finance(MOOC/SWAYAM/NPTEL)	2	0	0	2	2	50	50	100
PC-15	19BT6DCBIN	Bioinformatics	2	1	1	4	5	50	50	100
PC-16	19BT6DCETK	Enzyme Technology & Kinetics	2	1	1	4	5	50	50	100
PC-17	19BT6DCGAP	Genomics & Proteomics	3	0	0	3	3	50	50	100
PE-3	19BT6DEPE-3	Professional Elective 3	3	0	0	3	3	50	50	100
PE-4	19BT6DEPE-4	Professional Elective 4	3	0	0	3	3	50	50	100
SR-3	19BT6DCSEM	Seminar Based on Summer/Winter Internship (MOOC/SWAYAM/NPTEL)	0	0	1	1	1	50	50	100
PW-4	19BT6DCPRW	PW 2 Multidisciplinary Project (Among the clusters)	0	0	2	2	2	50	50	100
OE1	19BT6IEHAN/ 19BT6IEATE	Health and nutrition/ Alternative Energy	3	0	0	3	3	50	50	100
NC	19BT6NCIPR	Intellectual property rights	Non-Credit Mandatory course							
TOTAL			**18**	**2**	**5**	**25**	**27**	**450**	**450**	**900**

PE-3	19BT6DE3ABT	Animal Biotechnology	3	0	0	3	50	50	100
	19BT6DE3PCA	Process Control & Automation	3	0	0	3	50	50	100
	19BT6DE3STN	Signal Transduction	3	0	0	3	50	50	100

PE-4	19BT6DE4FBT	Food Biotechnology	3	0	0	3	50	50	100
	19BT6DE4GIN	Genome Informatics	3	0	0	3	50	50	100
	19BT6DE4BIM	Biomaterials	3	0	0	3	50	50	100

V SEMESTER SYLLABUS

Course Title	ENTREPRENEURSHIP										Credits	2		
Course Code	1	9	B	T	5	H	S	E	N	P	L-T-P	2	0	0

COURSE PRE-REQUISITES: Basics of entrepreneur, Market basics, Business plan preparation, Networking.

COURSE DESCRIPTION: The course provides the foundation for small business and an overview of business concepts, including topics such as: theories of entrepreneurship, types and characteristics of entrepreneurship, the business life cycle, entrepreneurial economics, accounting and financial management, legal issues, marketing research and planning, human resource management, ethics and social responsibility, product and service research development and acquisition, and the use of technology. This course discusses innovative and contemporary approaches in addressing areas such as: starting, acquiring a business, succeeding in business, and franchising a small business venture.

COURSE OBJECTIVES: To enable students to the opportunities and challenges associated with the creation and management of entrepreneurial and small organizations.

UNIT - 1

CONCEPT OF ENTREPRENEUR [5L]

Meaning, evolution of the concept, functions of an Entrepreneur, Characteristics of an Entrepreneur, types of entrepreneur, Intrapreneur– an emerging class. Difference between Entrepreneur, Intrapreneur & Manager, Stages in Entrepreneurial process, Scope of Entrepreneur & Problems of Entrepreneur,

Role of Entrepreneurs in economic development.

UNIT - 2

INTRODUCTION TO ENTREPRENEURSHIP [4L]

Meaning & Importance of Entrepreneurship in India. Its barriers, agencies in entrepreneurship management and future of entrepreneurship. Women entrepreneur – Concept & steps to develop Women Entrepreneur.

UNIT – 3

IDEA GENERATION AND SKILL SETS [5L]

Self-Assessment of Qualities, Skills, Resources and Dreams, Generation of Ideas; Business Ideas vs. Business Opportunities, Opportunity Assessment – Factors, Micro and Macro Market Environment, Feasibility Study, practical & economic feasibility, Business Plan Preparation; Execution of Business Plan, Business practice risk assessment, Role of networking in entrepreneurship, , Relevant case studies: strategy development exercise in business development

UNIT - 4

MARKET UNDERSTANDING **[4L]**

Business Idea and Concept, Types of Business: Manufacturing, Trading and Services. Stakeholders: sellers, vendors and consumers and Competitors, Market Research - Concept, Importance and Process, Market Sensing and Testing Business Model, Proof of Concept, Pricing and Factors affecting pricing. Launch Strategies after pricing and proof of concept.

UNIT – 5

RESOURCE MOBILIZATION **[8L]**

Types of Resources - Human, Capital and Entrepreneurial tools and resources, Selection and utilization of human resources and professionals like Accountants, Lawyers, Auditors, Board Members, etc. Role and Importance of a Mentor, Estimating Financial Resources required. Methods of meeting the financial requirements – Debt vs. Equity, Size and capital based classification of business enterprises. Various sources of Information; Incubators and Accelerators.

PRIMARY REFERENCES

1. Entrepreneurship and Management- S Nagendra and V S Manjunath- Pearson Publication 4 /e, 2009.
2. Dynamics of Entrepreneurial Development and Management-Vasant Desai-Himalaya Publishing House.

SECONDARY REFERENCES

1. Entrepreneurship Development – Poornima M Charanthimath Pearson Education 2006.
2. Entrepreneurship and management - Shashi k Gupta- Kalyani publishers, Latest edition.
3. Organizational behaviour, Stephen P Robbins, Timothy A. Judge, Neharika Vohra, Pearson, 14/e, 2012.
4. Financial Management- Shashi k Gupta- Kalyani publishers, Latest edition.

MOOCs

1. https://nptel.ac.in/courses/110/106/110106141/ **2.** https://nptel.ac.in/courses/110/107/110107094/

COURSE OUTCOMES (COs)

1. Get an in depth knowledge of Entrepreneurial process & will be able to apply the Entrepreneurial skills.
2. Compile information & apply the techniques to explore the business opportunities. (PO1)
3. Able to prepare and analyse a business plan by using various tools and skill sets. (PO2, PO1)
4. Select and apply the process of Market Research. (PO1)

Course Title	REACTION ENGINEERING										Credits	3		
Course Code	1	9	B	T	5	D	C	R	E	N	L-T-P	2	1	0

COURSE PRE-REQUISITES: Microbiology, Process Engineering Thermodynamics and Process Principles and Calculations.

COURSE DESCRIPTION: This course deals with the study of ideal and non-ideal bioreactors. The course also gives an insight into the concepts behind ideal chemically reacting systems represented by batch, continuous stirred tank reactors and plug-flow reactor and elementary steps involved to yield a reaction rate expression. It emphasizes on models for dealing with non-ideal flow reactors and the use of residence time distributions to predict the performance of reactions. It also describes the methods to predict yield coefficients using stoichiometric principles and energetics of microbial growth.

COURSE OBJECTIVES: The course objective is to enable students to differentiate between various reactors. Students will be able to understand the performance of ideal and non-ideal reactors by making use of design equations and various models. Students will also know about the criteria for scale-up of bioreactors and factors on which selection of bioreactors depends. On completion of the course, students will be able to determine yield coefficients using microbial growth kinetics.

UNIT - 1

REACTION KINETICS

[5L+3L]

Law of mass action and rate equation, definitions and examples of elementary and non-elementary reactions, theories of reaction rate and temperature dependency, analysis of experimental reactor data: evaluation of rate equation, half-life method, integral and differential analysis for constant volume system. Conceptual numericals.

UNIT - 2

IDEAL BIOREACTORS [6L+3L]

Design equations for homogeneous system: batch, stirred tank and tubular flow reactor, size comparison of reactor systems, combination reactor systems, recycle reactors. Conceptual numericals.

UNIT - 3

NON-IDEAL BIOREACTORS [6L+2T]

Non-ideal reactors: residence time distribution studies, pulse and step input response of reactors,

RTD's for CSTR and PFR, calculations of conversions for First order reactions, One parameter models - tanks in series and dispersion models. Zero Parameter Models, Conceptual numericals

UNIT - 4

KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION [3L+2T]

Phases of cell growth in batch cultures; simple unstructured kinetic models for microbial growth - Monod model; Growth associated (primary) and non-growth associated (secondary) product formation kinetics; Leudeking-Piret models; substrate and product inhibition on cell growth and product formation; Continuous culture; Conceptual numericals.

UNIT - 5

DESIGN AND ANALYSIS OF BIOREACTORS [7L+2T]

Stability and analysis of bioreactors, biomass production and effect of dilution rate. Design and operation of various bioreactors, eg. CSTF, fedbatch systems, airlift bioreactors, fluidized bed reactors, scale up of bioreactors - Scale-up and Scale-down of bioreactors - strategies and methods for scale-up, similarity criteria, Hubbard method, method of Wang et al., Ettler's method, dimensionless numbers and scale up, scale up based on aeration and power requirement (Aeration and Power number), regime analysis and the scale-down bioreactor, criteria for selection of bioreactors.

PRIMARY REFERENCES

1. Chemical Reaction Engineering by Levenspiel O., John Wiley, Third Edition, 2006.
2. Elements of Chemical Reaction Engineering by Fogler, H.S., Prentice Hall, 1986.
3. Bioprocess Engineering by Shuler and Kargi, Prentice Hall, Second Edition, 2005.

SECONDARY REFERENCES

1. Bioprocess Engineering by Aiba, Humprey & Millis, Academic Press, Second Edition, 1973
2. Biochemical Engineering by James Lee, Prentice Hall, 1992.
3. Biochemical Engineering Fundamentals by Bailey and Ollis, McGraw Hill, Second Edition, 1986.
4. Bioprocess Engineering Principles by Pauline M. Doran, Academic Press, 1995.

e-BOOKS

1. https://4lfonsina.files.wordpress.com/2012/11/levenspiel-chemical-reaction-engineering.pdf
2. http://www.docs-engine.com/pdf/1/bioprocess-engineering-kargi-shuler.html

MOOCs

1. http://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biological-reactionengineering-spring-2007/syllabus/

2. http://www.nptelvideos.in/2012/11/chemical-reaction-engineering.html

COURSE OUTCOMES (COs)

1. Select bioreactor for a given criteria and describe scale-up process.
2. Apply kinetics equations using different methods to determine chemical and biochemical reaction rates and residence time distributions in reactors. (PO1)
3. Identify, interpret and Analyse design equations for different reactors at steady state and solve reactor engineering, scale-up and microbial kinetics problems. (PO2)
4. Comprehend research articles based on reaction kinetics and individually interpret the methods and results. (PO9, PO10)

Course Title	GENETIC ENGINEERING										Credits	4		
Course Code	1	9	B	T	5	D	C	G	E	N	L - T - P	3	0	1

COURSE PRE-REQUISITES: Cell & molecular biology, Biochemistry, Basics of Biomolecules, Microbiology.

COURSE DESCRIPTION: The course describes various tools and techniques available for detection, isolation, amplification and manipulation of genes. The course deals with the biological, chemical and physical gene transfer methods as well as factors influencing gene expression. The course concludes with the applications of genetic engineering in production of GMOs.

COURSE OBJECTIVES: To impart in depth knowledge on strategies of gene cloning and its applications as well as giving hands on experience in gene manipulation.

PART A– THEORY

UNIT – 1

MOLECULAR TOOLS FOR GENE CLONING [6L]

Scope and objectives of gene cloning, Method of creating recombinant DNA molecules; Enzymes for gene manipulation: Nucleases (exo- and endonucleases, RNAses), polymerases (DNA and RNA polymerases, reverse transcriptases), Ligases, Restriction enzymes, Modifying enzymes: Alkaline phosphatases, polynucleotide kinases, terminal transferases. Methylases: CpG Methylase, Dam Methylase, Dcm Methylase. Linkers and adaptors.

UNIT - 2

VECTORS FOR GENE CLONING [10L]

Purpose, rationale of construction, cloning vectors: bacterial (plasmids, bacteriophages, cosmids, phagemids), yeast (yEPs, yIPs, yRPs, YACs), Shuttle vectors, viral vectors (retro and adeno), Plant vectors (Ti and Ri plasmids) and expression vectors (bacterial, animal cell and plant), Heterologous gene expression: strong and weak promoters, regulators. Factors influencing translational efficiency- RB sites, SD sequences, codon optimization, host cell biology in folding, solubility and post translational modification compatibilities.

UNIT – 3

TECHNIQUES FOR NUCLEIC ACID ISOLATION, DETECTION, LABELING, AMPLIFICATION [10L]

Isolation and purification of nucleic acids (genomic/plasmid/phage DNA and RNA), Polymerase chain reaction (PCR) variants and applications, Nucleic acid detection: Labeling (DNA and RNA by radio- and fluorescent methods), Southern blotting, northern blotting, Southwestern blotting and western blotting. Nucleic acid mutagenesis in vivo and in vitro, Construction of cDNA library, Construction of Genomic library, Screening of DNA libraries: Sequence-dependent screening (colony and plaque hybridization) and immunological screening.

UNIT - 4

GENE TRANSFER TECHNIQUES [6L]

Biological methods: Bactofection and Transduction. Chemical methods: Calcium phosphate, DEAE dextran, Cationic Lipid and poly-L-lysine (PLL). Physical: Electroporation, Microinjection, Particle Bombardment, Sonoporation, Laser induced. Biological: Agrobacterium mediated gene transfer in plants (Ti & Ri plasmids), Chloroplast transformation: Vector design and applications.

UNIT - 5

APPLICATIONS [7L]

Plants: Herbicide, pest and stress resistant plants, improvement of nutritional quality and Increase in shelf life, methods of producing transgenic animals (mice) and their uses. Gene therapy- types of gene therapy, gene therapy for SCID and cancer, Animal cloning. Gene targeting, RNAi technology, Genome editing: CRISPR technology.

PRIMARY REFERENCES

1. Introduction to Genetic Engineering by Nicholl. Cambridge Low Price Edition.
2. Principles of Gene Manipulation and Genomics by S.B. Primrose and R.M. Twyman, 7th edition
3. Gene Cloning and DNA Analysis: An Introduction 6th Edition by T. A. Brown. Blackwel Publications
4. Molecular cloning:a laboratory manual by Green and sambrook
5. Current protocols in Molecular biology by Frederic Ausubel

SECONDARY REFERENCES

1. From Genetics to Gene Therapy – the molecular pathology of human disease by David S Latchman, BIOS scientific publishers, 1994.
2. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick, B R, Pasternak .J J, 2003, Third edition, DC ASM Press.

e-BOOKS

1. Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.

2. Molecular Cell Biology. 4th edition. Lodish H, Berk A, Zipursky SL, et al.New York: W. H. Freeman; 2000.

MOOCs

1. http://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/

2. http://nptel.ac.in/courses/102103013/3

PART B: GENETIC ENGINEERING AND IMMUNOTECHNOLOGY

LABORATORY

1. DNA quantification (Plant/Animal/Bacteria)
2. PCR: gene /DNA amplification
3. Restriction digestion, agarose gel electrophoresis and size determination.
4. Transformation.
5. Phage titration
6. Agglutination Techniques
7. Single Radial Immunodiffusion (SRID)
8. Ouchterlony Double Diffusion (ODD)
9. Rocket & Counter current immune-electrophoresis (RIEP)
10. Qualitative ELISA
11. Dot ELISA
12. Western blot (demo)

COURSE OUTCOMES (COs)

1. Understand, Relate, compare and contrast application of various tools in gene manipulation. (PO1)
2. Apply a suitable gene transfer methods and factors influencing its expression. (PO1, PO5)
3. Apply a suitable approach for isolation, purification, amplification and detection of nucleic acids as well as for design and construction of a DNA/cDNA library. (PO1, PO5)
4. Apply the concepts and tools for gene manipulation in development of GMOs. (PO1, PO5, PO12)
5. Design and conduct experiments related to gene manipulation as well as analyse and interpret data. (PO4)

Course Title	BIOPROCESS TECHNOLOGY										Credits	4		
Course Code	1	9	B	T	5	D	C	B	P	T	L-T-P	2	1	1

COURSE PRE-REQUISITES: Microbiology, Basics of biomolecules, Unit operations, Biochemistry, Genetic engineering, Bio analytical techniques, Reaction engineering.

COURSE DESCRIPTION: This course emphasizes on applications of microorganisms in fermentation industry. Students will be introduced to various fermentation processes, basic design of the fermenter, media formulation and different aseptic techniques used in the fermentation industries. Student will be exposed to various downstream processing techniques to recover and purify value added products.

COURSE OBJECTIVES: This course is designed to illustrate the applications of micro-organisms in fermentation industry. This course also imparts good operational knowledge on design of fermenter, aseptic operations and separation techniques to develop and recover value added products from living organisms. Further students will be able to handle fermenter, design media, optimize process parameters and differentiate between different separations techniques to design a combination of downstream techniques for a given process to provide bioprocess engineering solutions.

PART A– THEORY

UNIT - 1

ISOLATION, STRAIN IMPROVEMENT AND DEVELOPMENT OF MICROBIAL INOCULA [5L+2T]

The Range of Fermentation processes, industrially important microorganisms, screening of Microorganisms, Preservation and strain improvement (Mutant selection, Recombinant DNA methods) of industrially important Micro-organisms. Development of inocula for industrial fermentations – criteria for inoculum transfer, development of inocula for yeast, bacterial and mycelia processes.

UNIT - 2

MEDIA FORMULATION AND PROCESS OPTIMIZATION [6L+4T]

Functional requirements of Fermenters and Basic design, types of fermenters, Aseptic operation and Containment; Media formulation and optimization, Design of batch and continuous sterilization. Achievement and maintenance of aseptic condition: Sterilization of fermenter(SIP,FSIP,ESIP), air supply and exhaust gas from a fermenter, addition of inoculum, nutrients and other supplements, sampling, feed ports, sensor probes. Aeration and Agitation. Instrumentation and Control of various operational parameters (pH, Temperature, Pressure, Agitation, Antifoam, P_{O2}).

UNIT - 3

SCOPE OF DOWNSTREAM PROCESSING

[5L+3T]

Role and importance of downstream processing. criteria for selection of bio-separation techniques. Characteristics of biological mixtures, Process design Criteria with flow charts for various classes of byproducts (Cases studies for high volume-low value products and low volume-high Value products), Cell disruption methods for intracellular products. Filtration methods.

UNIT - 4

MEMBRANE ENRICHMENT OPERATIONS **[5L+2T]**

Use of membrane diffusion as a tool for separating and characterizing naturally occurring Polymers; solute polarization and cake formation in membrane ultra-filtration – causes, consequences and control techniques; enzyme processing using ultra filtration membranes; separation by solvent membranes; ultra-filtration and reverse osmosis; Membrane – based separations (Micro- and Ultra-filtration) theory; design and configuration of membrane separation equipment; applications; precipitation methods with salts, organic solvents and polymers, supercritical extraction; In-situ product removal/integrated bioprocessing.

UNIT - 5

SECONDARY PRODUCT SEPARATION TECHNIQUES AND PRODUCT RECOVERY

[5L+2T]

Liquid-liquid extractions, Crystallization: Principles of crystallization, crystallization equipment. Drying: Various types of drying methods, principles of drying, various types of industrial dryers and their criteria for choice. Freeze drying technique.

PRIMARY REFERENCES

1. Principles of Fermentation Technology by P.F. Stanbury, A. Whitkar and S.J. Hall, 1997, Aditya Book, New Delhi.
2. Bioseparation – Downstream processing for biotechnology by Belter P.A., Cussier E. and WeiShan Hu., Wiley Interscience Pub, 1988.
3. Bioseparations by Belter P.A. and Cussier E., Wiley, 1985.
4. Product Recovery in Bioprocess Technology - BIOTOL Series, VCH, 1990

SECONDARY REFERENCES

1. Biochemical Engineeringby Bailey and Ollis, McGraw Hill Publisher.
2. Fermentation advancesby Perlman. D (Ed), Aca press, New York.
3. Bioprocess Engineeringby Shuler and Kargi Prentice Hall, 1992.

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1. http://www.springer.com/us/book/9780751403640
2. http://ebookszones.blogspot.in/2011/05/principles-of-fermentation-technology_23.html

MOOCs

1. http://nptel.ac.in/courses/102106022/
2. https://www.class-central.com/tag/bioprocess

PART B – BIOPROCESS TECHNOLOGY LABORATORY

1. Cell disruption techniques
2. Solid – Liquid separation methods: Filtration **3.** Solid – Liquid separation methods: Centrifugation **4.** Phytochemical extraction and estimation.
5. Callus induction and preparation of artificial seed.
6. Separation of Amino acids / Carbohydrates by TLC
7. Production and estimation of Citric acid from fermented broth
8. Production and estimation of Penicillin.
9. Medium Design – a) PLACKETT – BUKMAN design for media.
   b) Response surface methodology for media design
10. Sodium sulphite oxidation method for determination of Mass Transfer coefficient.
11. Dynamic gassing method for determination of Mass Transfer coefficient.
12. Qualitative and quantitative analysis of biomolecules by HPLC (demo)
13. Freeze drying technique for product concentration (demo)

COURSE OUTCOMES (COs)

1. Comprehend and apply the inoculum development and strain improvement techniques for a desired fermentation process. (PO1)
2. Select a fermenter and formulate suitable media for a desired fermentation process. (PO1, PO3)
3. Apply techniques and processes for batch and continuous sterilization and solve related problems. (PO1, PO2, PO5)
4. Apply various downstream techniques for product isolation, separation and purification. (PO1, PO5)
5. Conduct experiments for production, isolation and recovery of bio - products. (PO4)

Course Title	BIOANALYTICAL TECHNIQUES										Credits	3		
Course Code	1	9	B	T	5	D	C	B	A	T	L-T-P	3	0	1

COURSE PRE-REQUISITES: Engineering Physics, Engineering Chemistry, Engineering Mathematics, Basics of Biomolecules

COURSE DESCRIPTION: this course deals with the principle, instrumentation and application of various biophysical techniques used for the separation of biomolecules and characterization of these biomolecules. It also describes the various methods used for the separation and purification of the various biomolecules

COURSE OBJECTIVES: To enable the students to gain knowledge on the various techniques for bimolecular separation, purification and characterization.

PART A– THEORY

UNIT - 1

CHROMATOGRAPHIC TECHNIQUES [9L]

Classification of chromatography, Basic parameters: partition coefficient, retention time and volume, elution time and volume, column efficiency, resolution and related numericals, internal and external standards. Planar Chromatography: Principle, apparatus, solvent system, detection and applications of Paper chromatography (ascending, descending and 2D) and Thin layer chromatography.

Column chromatography: Principle, instrumentation, matrices, solvent system, detection and applications of Ion exchange chromatography, Gel filtration chromatography, Affinity chromatography, Gas liquid chromatography and High performance liquid chromatography.

UNIT - 2

ELECTROPHORESIS [7L]

Principle, Design of horizontal and vertical gelelectrophoresis apparatus, performing electrophoresis techniques, isoelectric focusing, native PAGE, SDS-PAGE, Pulse field and immuno,electrophoresis, application of electrophoresis in analyzing macromolecules.

UNIT - 3

BIOPHYSICAL TECHNIQUES [9L]

Principle, instrumentation and applications of Rayleigh scattering, analytical and preparative ultracentrifugation, viscometry. SEM, TEM, Scanning tunneling microscopy, AFM, luminescence (fluorescence & phosphorescence), Flame photometry, Atomic absorptiomn spectroscopy, Isothermal and differential calorimetry, Mass spectrometry: LC-MS, MALDI-TOF.

UNIT - 4

STRUCTURAL INVESTIGATION OF MACROMOLECULES [9L]

Principle, instrumentation and application of X-ray (single crystal diffraction, fiber diffraction and neutron diffraction), XAFS, ESR / EPR, NMR, CD, UV, IR, Raman Spectroscopy.

UNIT - 5

RADIOISOTOPIC TECHNIQUES [5L]

Basic concepts, GM and scintillation counter, autoradiography, safety aspects and applications in biological science.

PRIMARY REFERENCES

1. Biophysical Chemistry by Cantor R., and Schimmel P.R
2. Physical Biochemistry by David Freifelder (N H Freeman and Company)
3. Biophysical Principles of Structure & Function by Fred M. Snell & Sidney Shulman **4.** Separation processes in biotechnology by Asenjo J and M. Dekker, CRC Publishers. 1993.
5. Bioseparations by Belter P.A and Cussier E.Wiley. 1985.
6. Bioseparations by Harrison R.G. Todd P. Rudge S.R. and D.P. Petrides. Science and Engineering Oxford University Press, 2004.
7. Basic separation techniques in biochemistry by Okotore R.O.New Age International. 1998.
8. Physical Chemistry: Principles and Applications in Biological Sciences by Tinoco and others (Prentice Hall, 4th Ed).

SECONDARY REFERENCES

1. Biophysics – An Introduction by Cotterill, Wiley Student Edition
2. Foundations of Biophysics by A.L. Stanford.
3. Principles of protein structure by G Schulz and R H Schrimer (Springer Verlag)
4. Principles of nucleic acid structure by Sanger (Springer Verlag)
5. Introduction to Protein Science by Arthur M Lesk (OUP)
6. Biological Spectroscopy by J. D. Campbell and R. A.Dwek
7. Proteins – Structure & Molecular Properties by Creighton

e-BOOKS

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson https://books.google.co.in/books?isbn=052165873X

2. Biophysical Techniques by Iain Campbell https://0b9411cb7057497b22db0cd9f69e827bce11ede8.googledrive.com/host/0B5XjjBGDoIrhNlFVcVhQWjA2a1k/Biophysical-Techniques-Iain-Campbell-ebook-51iBvNTIHhL.pdf

MOOCs

1. http://nptel.ac.in/courses/102107028/
2. http://nptel.ac.in/courses/102103044/

PART B: BIOANALYTICAL TECHNIQUES LABORATORY (2hrs/week)

1. Separation of mixture of amino acids /sugars/plant pigments etc by TLC
2. Separation of proteins by Gel filtration
3. Determination of caffeine via HPLC
4. HPLC separation of phytochemicals
5. Resolve proteins by native PAGE
6. Determination of molecular weight of proteins by SDS PAGE
7. Isoelectric focussing of proteins
8. Resolve nucleic acids by agarose gel electrophoresis
9. Determine melting temperature and % GC content of the given DNA sample
10. Investigating Protein: Nucleic Acid Interactions by Electrophoretic Mobility Shift Assay (EMSA)

COURSE OUTCOMES (COs)

1. Select technique (s) that can be applied for a biomolecule separation and elucidate the principle and method. (PO1,5)
2. Select technique (s) that can be applied for a biomolecule purification and elucidate the principle and method. (PO1,5)
3. Select and apply suitable techniques for identification of biomolecules. (PO1,5,12)
4. Select and apply suitable techniques for characterization of biomolecules. (PO1,5,12)
5. Design, conduct experiments related to quantitative analysis of biomolecules and interpret data (PO 4)
6. Engage in independent learning and work effectively as an individual to carry out literature search effectively, design, conduct experiments & interpret data and write a technical report (PO4,9,10)

Course Title	MULTI DISCIPLINARY PROJECT 1										Credits	2		
Course Code	1	9	B	T	5	D	C	P	R	W	L-T-P	0	0	2

COURSE PRE-REQUISITES: Engineering Physics, Engineering Chemistry, Engineering Mathematics and all other subjects of the previous semesters related to the multidisciplinary project.

COURSE DESCRIPTION:

The field of biotechnology has become more quantitative and interdisciplinary as research in biotechnology continues to grow at a tremendous rate with broader and complex applications in medicine, agriculture, the environment and nanobiotechnology. As biological concepts and models become more quantitative, biological research will be increasingly dependent on concepts and methods drawn from other scientific disciplines. Therefore, in order to prepare our undergraduate life science students to be future research scientists, we need to transform undergraduate education. This will require life science majors to develop and reinforce connections between biology and other scientific disciplines so that interdisciplinary thinking and work becomes second nature.

The students are expected to opt for the project based around real-world open problems involving both biological as well engineering aspects of Biotechnology and are required to explore biological systems to develop new technologies, tools and products that are useful in research, industry and agriculture. Market research/case studies for biological/biotechnological products,

The aim of the course is to train the student to working in a multidisciplinary project based development work, in which the student is expected to acquire knowledge on project by carrying out extensive literature review, compile, analyse and interpret the collected data and define the problem definition.

COURSE OBJECTIVES:

1. To develop a creative attitude to the development and manufacture of biotechnology products using multidisciplinary approach.
2. To train leadership and teamwork via the multidisciplinary project.
3. To prepare the students for industry as well as research programs by imparting professional skills development.

COURSE OUTCOMES (COs)

1. Comprehend a given problem pertaining to biotechnology which involves multidisciplinary approach. (PO1, PO6, PO7, PO8)
2. Carry out the extensive literature review, compile, analyse and interpret the collected data and define the problem definition. (PO2, PO3, PO4, PO5, PO12)
3. Write effective report and communicate effectively by oral presentation. (PO10)

Course Title	IMMUNOTECHNOLOGY										Credits	3		
Course Code	1	9	B	T	5	D	E1	I	M	M	L-T-P	3	0	0

COURSE PREREQUISITE: Cell and Molecular Biology, Basics of Biomolecules and Biochemistry, Microbiology.

COURSE DESCRIPTION: course includes structure and function of immune cells and organs, detailed aspects of immune response, the molecular mechanisms of immunity. The course also deals with role of immune system in health and disease, preventive therapies and modern techniques in immunology

COURSE OBJECTIVES: To impart Knowledge on immune mechanisms operating in the body for combating infections and role of immune system in health disease. The student will be able to understand the intricacies of vaccine Design, transplant rejection and production of antibodies.

UNIT – 1

INTRODUCTION TO IMMUNE SYSTEM **[6 L]**

Historical development, Overview of immune response, cells of immunesystem: role of macrophages, neutrophils, Basophils, eosinophils and Dendritic cells, innate and acquired immunity, Passive and active immunity, primary and secondary lymphoid organs, antigens: chemical and molecular nature, clonal selection theory, humoral and cellular immunity.

UNIT – 2

[10 L]

B-Cells: Types, structure and function of Immunoglobulins, development of B-Cells, B cell receptor, recognition of antigen, activation and differentiation. Genetic organization of Immunoglobulin Genes, expression and secretion. Antigen processing and presentation. Major Histocompatibility Complex and HLA.

T-CELLs and NK cells: Types of T-cells, Activation and function of T-cells, T cell receptors, Co receptors and other surface markers, antigen presenting cells, antigen processing and presentation, Major histocompatibility Complex- MHC Class I and II molecules, CTLs and NK cells: activation, differentiation and function.

UNIT - 3

IMMUNE SYSTEM IN HEALTH & DISEASE [10L]

The Complement System: Classical, Alternate and MBL pathways. Hypersensitivity Reactions: Type I, II, III and IV. Immunodeficiency disorders: Primary and Secondary, Autoimmunity: autoimmune disorders (autoimmune haemolytic anemia, myasthenia gravis, systemic lupuserythematosus, multiple sclerosis, rheumatoid arthritis), mechanism, cancer immunotherapy**,** Transplantation and Tumor Immunology - Relationshipbetween donor and recipient, role of M H C molecules in allograft rejection, bone marrow and haematopoietic stem cell transplantation, tumor antigens, categories of tumor antigens, tumorimmunoprophylaxis.

UNIT – 4

VACCINES AND THERAPEUTIC ANTIBODIES [6 L]

Vaccines: Design strategies, Whole organism, Subunit and synthetic vaccines. Therapeutic Antibodies: Immuno-toxins, antibody hetero-conjugates, chimeric and humanized minibodies, antibody mimics (adnectins, affibodies). Production of polyclonal antibodies, production of monoclonal antibodies by hybridoma technology and r-DNA technology

UNIT – 5

IMMUNOTECHNIQUES [7 L]

Antigen – Antibody Reactions, Affinity, Avidity, Cross-Reactivity, Immunoprecipitations, Precipitation Reactions, Agglutination Reactions, Radioimmunoassay, Enzyme-linked Immunosorbent Assay, Western Blot, Immuno-electrophoresis. Immuno-fluorescence, fluorescence activated cell sorting analysis, cytotoxicity assay.

PRIMARY REFERENCES

1. Kuby Immunology by Kindt, Thomas J., Osborne, Barbara A., Goldsby, Richard A. W.H. Freeman & Co, Fifth edition, 2003.
2. The Principles of Immunology by H.T. Karsner, E.E. Ecker. Publisher: Lippincott 1921 ISBN/ASIN: B005GEE560

SECONDARY REFERENCES

1. Immunology 4th Edition by Ivan Roitt (Author), David Male (Author), Johathan Brostoff (Author). ISBN-10: 0723421781
2. Review of Medical Microbiology and Immunology by Warren Levinson ,Lange Medical Books, 13th Edition.

e-BOOKS

1. Immunology: With STUDENT CONSULT Online Access, 8e (Immunology (Roitt)) 8th Edition by David Male MA PhD (Author), Jonathan Brostoff MA DM DSc(Med) FRCP FRCPath (Author), David Roth MD PhD (Author), Ivan Roitt.

2. Janeway, Charles A., et al. Immunobiology: The Immune System in Health and Disease. New York, NY: Garland Science, 2004. ISBN: 9780443073106.

MOOCs

1. https://www.mooc-list.com/course/bioc3721x-fundamentals-immunology-part-1- edx?static=true
2. http://nptel.ac.in/courses/102103038/download/module1.pdf

COURSE OUTCOMES (COs)

1. Distinguish various types of antibody molecules and explain their production and applications as therapeutics (PO1)
2. Draw structure of immune cells, organs and molecules, relate their role in immune defence (PO1)
3. Describe the role of immune system in health, disease and transplantation (PO1 and
4. PO6)
5. Describe various parameters in design of vaccines (PO12 and PO6)
6. Conduct experiments involving detection and quantification of antigens, antibodies and pathogens. (PO4)

Course Title	TRANSPORT PHENOMENA										Credits	3		
Course Code	1	9	B	T	5	D	E1	T	P	N	L-T-P	3	0	0

COURSE PRE-REQUISITES: Knowledge of Unit operations-1 and Unit operations-2.

COURSE DESCRIPTION: This course deals with the study of transport phenomena in molecular motion. The course gives an insight into the concepts of transport process in laminar and turbulent conditions. It also emphasizes on the applications of equation of change. This course describes the analogies between transport processes.

COURSE OBJECTIVES: The course objective is to enable students to describe mass, momentum and energy transport at molecular, microscopic and macroscopic level, to determine velocity, temperature and concentration profiles.

UNIT 1

TRANSPORT PHENOMENA BY MOLECULAR MOTION [7 L]

Importance of transport phenomena; concepts, conservation laws; continuous concept, field, reference frames, substantial derivative and boundary conditions; Phenomenological laws of transport properties Newtonian and non-Newtonian fluids; rheological models; theories of transport properties of gases and liquids; Effect of pressure and temperature.

UNIT 2

ONE DIMENSIONAL TRANSPORT IN LAMINAR FLOW (SHELL BALANCE) [10 L]

General method of shell balance approach to transfer problems; Choosing the shape of the shell; most common boundary conditions; momentum flux and velocity distribution for flow of Newtonian and non-Newtonian fluids in pipes for flow of Newtonian fluids in planes, slits and annulus heat flux and temperature distribution for heat sources such as electrical, nuclear viscous and chemical;

UNIT 3

EQUATIONS OF CHANGE AND THEIR APPLICATIONS [10 L]

Conservation laws and equations of change; Development of equations of continuity motion and energy in single multicomponent systems in rectangular co-ordinates and the forms in curvilinear coordinates; simplified forms of equations for special cases, solutions of momentum mass and heat transfer problems discussed under shell balance by applications of equation of change, scale factors; applications in scale-up.

UNIT 4

TRANSPORT IN TURBULENT AND BOUNDARY LAYER FLOW [7 L]

Turbulent phenomena; phenomenological relations for transfer fluxes; time smoothed equations of change and their applications for turbulent flow in pipes; laminar and turbulent hydrodynamics thermal and concentration boundary layer and their thicknesses; analysis of flow overflat surface.

UNIT 5

ANALOGIES BETWEEN TRANSPORT PROCESSES [5 L]

Importance of analogy; development and applications of analogies between momentum and mass transfer; Reynolds, Prandtl, Von Karman and Colbum analogies.

PRIMARY REFERENCES

1. **Transport Phenomena** by R.B. Bird, W.E. Stewart and E.W. Lightfoot, John Wiley, II Edition 2006.
2. **Transport Phenomena A Unified Approach** by Robert, S Brodkey, Harry C. Hershey, Brodkey Publishing 2003.

SECONDARY REFERENCES

1. **Elements of Transport Phenomena** by L.S.Sissom, and D.R.Pitts, McGraw-Hill, New York, 1972.
2. **Elementary Transport Phenomena** by R.W.Fahien,, McGraw-Hill, New York, 1983.
3. **Fundamentals of Momentum Heat and Mass Transfer** J.R. Welty, R.W. Wilson, and C.W.Wicks, Rorer G.E, Wilson R.W, V Edn. John Wiley, New York, 2007.

e-BOOKS

1. http://www.slideshare.net/Aapandove/bird-stewart-lightfoot-2002-transport-phenomena-2nd-ed

2.https://www.academia.edu/5797564/09_Transport_Phenomena_A_Unified_Approach._Robert_S._

B rodkey._Harry_C_Hershey?auto=download

MOOCs

1. https://www.edx.org/course/basics-transport-phenomena-delftx-tp101x-0
2. http://nptel.ac.in/courses/103106068/28

COURSE OUTCOMES (COs)

1. Comprehend one dimensional transport process and its applications in laminar flow and turbulent conditions.
2. Derive and apply equations for solving momentum, mass and heat transfer problems. (PO1)
3. Identify and analyze transport process involved in molecular motion. (PO2)
4. Comprehend research articles based on transport phenomena in biotechnology and individually **5.** interpret the methods and results. (PO9, PO10)

Course Title	MEMBRANE BIOLOGY										Credits	3		
Course Code	1	9	B	T	5	D	E1	M	E	B	L-T-P	3	0	0

COURSE PRE-REQUISITES: Basics of Biomolecules, Biochemistry and Bioenergetics, Cell and Molecular Biology

COURSE DESCRIPTION: This course focuses on the basic concepts of membrane biology. It explains the structure and functional aspects of biomembranes as well as the tools & techniques involved in their study .

COURSE OBJECTIVES: The course aims to give a basic knowledge of membrane biology and its importance.

UNIT-1

INTRODUCTION TO BIOMEMBRANES [9 L]

Composition of bio-membranes - prokaryotic, eukaryotic, neuronal and subcellular membranes. Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids.

Study of membrane proteins: Integral and membrane associated proteins. Fluid mosaic model with experimental proof. Monolayer, planer bilayer and liposomes as model membrane systems.

UNIT-2

MEMBRANE STRUCTURES [7 L]

Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers. CMC, critical packing parameter. Membrane asymmetry. Macro and micro domains in membranes. Membrane skeleton, lipid rafts, caveolae and tight junctions. RBC membrane architecture.

UNIT-3

MEMBRANE DYNAMICS [9 L]

Lateral, transverse and rotational motion of lipids and proteins. Techniques used to study membrane dynamics - FRAP, TNBS labeling etc. Membrane fluidity, factors affecting membrane fluidity.

UNIT-4

MEMBRANE TRANSPORT [7 L]

Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport - glucose transporter, anion transporter and porins. Primary active transporters - P type ATPases, V type ATPases, F type ATPases. Secondary active transporters - lactose permease, Na+ -glucose symporter.

UNIT-5

VESICULAR TRANSPORT AND MEMBRANE FUSION [7 L]

Types of vesicle transport and their function - clathrin, COP I and COP II coated vesicles. Molecular mechanism of vesicular transport. Membrane fusion. Receptor mediated endocytosis of transferrin.

PRIMARY REFERENCES

1. .Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641- 0962-1.
2. Molecular Cell Biology (2013) 7th ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., W.H. Freeman & Company (New York), ISBN:13:978-1-4641-0981-2.

SECONDARY REFERENCES

1. . Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning(Boston), ISBN-13:978-0-495-11464-2.
2. Principles of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., JohnWiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

e-BOOKS

1. https://books.google.co.in/books/about/Bioenergetics.html?id=0_9EWX1fg8wC&redir_esc=y
2. https://archive.org/details/LehningersPrinciplesOfBiochemistry5e

MOOCs

1. https://ocw.mit.edu/courses/biology/7-06-cell-biology-spring-2007/

COURSE OUTCOMES (COs)

1. Elucidate the diverse range of lipid functions from cellular compartmentalization to signaling in context of lipid biochemistry(PO 1))
2. Select technique (s)or tools that can be applied to study membrane dynamics and elucidate the principle and method. (PO1,5,12)
3. Identify the different membrane transport processes and their functional significance (PO2)
4. Identify the mechanism involved between lipids and proteins interface to achieve membrane fusion for exchange of materials between cells e.g. exocytosis, endocytosis, synaptic transmission. (PO 1,5 , 12)

Course Title	AGRICULTURAL BIOTECHNOLOGY										Credits	3		
Course Code	1	9	B	T	5	D	E2	A	G	T	L-T-P	3	0	0

COURSE PRE-REQUISITES: Microbiology, Basics of biomolecules, Biochemistry, Molecular biology, Genetic engineering,

COURSE DESCRIPTION: This course emphasizes on role of biotechnology in modern agriculture systems. Students will be introduced to various biotechnological tools which has potential to improve the yield, crop varieties, nutritional quality and resist against biotic and abiotic stresses. The course will also cover the economical aspect of agriculture related to investment vs income, risks carried and plant layouts.

COURSE OBJECTIVES: This course is designed to provide an overview of biotechnological role in modern agriculture which deviates from traditional agriculture system. Students will be able to gain knowledge on exploitation of totipotent character of plant cells to develop novel plant varieties, modern GE strategies to improve crop varieties, transfer novel and useful property and naturally acquire resistance against biotic and abiotic factors risks. Further students will be able to assess the economic factors behind agriculture system as profession.

UNIT-1

TISSUE CULTURE TECHNIQUES [9 L]

Basic techniques in cell culture and somatic cell genetics. Regulation of cell cycle and cell division.Clonal propagation. Concept of cellular totipotency. Anther culture, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. In vitro, mutagenesis, cryopreservation and plant tissue culture repository.

UNIT-2

PLANT GENETIC ENGINEERING [9 L]

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, viz. direct and vector-mediated. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement, i.e. insectpest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, Current status of transgenics, biosafty norms and controlled field trials and release of transgenics (GMOs).

UNIT-3

MICROBIAL INOCULANTS FOR PLANTS [7 L]

Biofertilisers- definition, types , metabolic pathways, microbial consortia, Large-scale production and field applications (N_2 fixers, Micorrhiza and phosphate solubilisers).

UNIT-4

MOLECULAR FARMING [6 L]

Plants and animals as living factories, Biopharmaceuticals from plants- biotechnologically designed vaccines, monoclonal antibodies and proteins. Biopolymers from plants- PHAs, Triglycerides for biofuel,

UNIT-5

PRODUCTION ECONOMICS [8 L]

Meaning, Definition, Nature and Scope of Agricultural Production Economics. Basic concepts and terms. Concepts of Production. Production Functions: Meaning, Definition, Types. Laws of returns: Increasing, Constant and decreasing. Factor Product Relationship. Determination of optimum input and output. Factor relationship. Product relationship. Types of enterprise relationships. Returns to scale: Meaning, Definition, Importance. Farm Management. Economic principles applied to the Organisations of farm business. Types and systems of farming. Farm planning and budgeting. Risk and uncertainty. Farm budgeting. Linear programming: Assumptions, Advantages and Limitations of Linear programming.

PRIMARY REFERENCES

1. Dhondyal. S.P.. "Farm Management -An Economic Analyst". Friends Publications. Merrut.
2. Doll. J .P .& Ozazem. F. "Production Economics Theory with application" Grid Inc. Columbus Chio.
3. Sankhayan. P .L. " Introduction to the Economics of Agricultural Production. Prentice Hall of India Pvt. Ltd. New Delhi.
4. Plant tissue culture, Bhojwani and Razdan

MOOCs

1. https://nptel.ac.in/courses/102/106/102106080/#
2. https://swayam.gov.in/nd2_nou19_ag08/preview

Course Title	R-PROGRAMMING										Credits	3		
Course Code	1	9	B	T	6	D	E2	R	P	G	L-T-P	3	0	0

COURSE PRE-REQUISITES: Basics of computer applications, Biostatistics & probability, Molecular Biology and Bioanalytical techniques. .

COURSE DESCRIPTION: This course emphasizes on basics of R programming and interfacing with statistics to analyse the data. It also portraits the fundamentals of Bioconductor an open source software tool for bioinformatics to analyse and interpret the Biological data.

COURSE OBJECTIVES: This course is designed to impart good operational knowledge on basics of R programming and interfacing with statistics for the computational analysis of data. This course also highlights the fundamentals and applications of Bioconductor an open source software tool for bioinformatics. Further students will inculcate these tools to critically analyse the data and derive valid conclusions.

UNIT- 1

R PROGRAMMING BASICS [7 L]

Overview of R programming, Environment setup with R Studio, R Commands, Variables and Data Types, Control Structures, Vectors, Factors, Functions, Matrices, Arrays and Lists.

UNIT- 2

INTERFACING [7 L]

Interfacing R to other languages, Parallel R, Basic Statistics: Linear Model, Generalized Linear models, Non-linear models, Time Series, Autocorrelation and Clustering.

UNIT- 3

BIOCONDUCTOR FOR SEQUENCE DATA [10L]

Sequencing Resources, Ranges Infrastructure, DNA /amino acid sequence from FASTA files, Reads from FASTQ files, Aligned Reads from BAM files, Called Variants from VCF files, Genome Annotations from BED, WIG, GTF files

UNIT- 4

BIOLOGICAL DATA ANALYSIS

[6 L]

Preparing count matrices, The DESeqDataSet, sample information, and formula design, exploratory analysis and visualization, Differential expression analysis, Plotting results, Annotating and exporting results

UNIT- 5

MASS SPECTROMETRY AND PROTEOMICS DATA ANALYSIS [9 L]

Exploring available infrastructure, Mass spectrometry data, Getting data from proteomics repositories, Handling raw MS data, Handling identification data, MS/MS database search, Analysing search results, Analysis of peptide sequences, Trimming the data, Parent ion mass error, Filtering criteria, Filter optimisation, High-level data interface, Quantitative proteomics, Importing third-party quantitation data, Data processing and analysis, Raw data processing, Processing and normalisation, Statistical analysis, Machine learning: Classification, Clustering: k-means, Annotation.

PRIMARY REFERENCES

1. An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics. W. N. Venables, D.M. Smith and the R Development Core Team. Version3.3.3.

2. Jared P. Lander, "R for Everyone: Advanced Analytics and Graphics", Addison- Wesley Data & Analytics Series, 2013.

SECONDARY REFERENCES

1. Norman Matloff, "The Art of R Programming: A Tour of Statistical Software Design", No Starch Press, 2011.
2. Avril Coghlan ,"A Little Book of R For Bioinformatics", Release 0.1

E-BOOKS

1. https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf
2. https://www.bioconductor.org/

MOOCs

1. https://www.class-central.com/tag/r%20programming
2. https://www.edx.org/course/introduction-r-data-science-microsoft-dat204x-3

COURSE OUTCOMES (COs)

1. Comprehend the basics of R programming and Bioconductor.
2. Apply statistical techniques using R Programming for analysis of data. (PO5)
3. Analyse and interpret the Biological data using the bioconductor tools. (PO2)

Course Title	BIOSENSORS AND BIOINSTRUMENTATION										Credits	3		
Course Code	1	9	B	T	5	D	E 2	B	B	I	L-T-P	3	0	0

COURSE PRE-REQUISITES: Knowledge of Engineering Chemistry, Basic Electrical Engineering, Elements of Electronics Engineering and Biology for Engineers.

COURSE DESCRIPTION: This course deals with the fundamentals of measurement science are applied to optical, electrochemical, and mass and pressure signal transduction.This course also examines the principles, technologies, methods and applications of biosensors and bioinstrumentation by bridging engineering principles to understanding of biosystems in sensors and bioelectronics.The Biosensors and Instrumentation course examines the methods used to interface sensors for biological and biomedical applications with electronics.

COURSE OBJECTIVES: To enable the students to gain knowledge on the various biosensors and bioinstrumentation techniques which are used in biomedical engineering field.

UNIT 1

FUNDAMENTALS OF MEDICAL INSTRUMENTATION [9L]

Sources of biomedical signals, Design of medical instruments, components of the biomedical instrumentation system, General constraints in design of medical instrumentation systems, Regulation of medical devices; Principles of EEG, ECG and EMG, Origin of bioelectric signals, Recording electrodes, - Electrode-tissue interface, metal electrolyte interface, electrolyte - skin interface, Polarization, Skin contact impedance, Silver – silver chloride electrodes, Electrodes for ECG, EEG, EMG.Physiological Transducers: Introduction, classification of transducers, performance characteristics of transducers, Classification, displacement, position, motion , pressure, temperature, photoelectric, optical fibre sensor transducers ; Conceptual numerical.

UNIT 2

BIOMEDICAL INSTRUMENTATION FOR CARDIOVASCULAR SYSTEMS [7L]

The measurement of heart rate; measurement of pulse rate; Types of blood pressure measurement: Indirect and Direct measurements; measurement of blood flow rate: Electromagnetic induction, ultrasound transmission, Thermal conversion, Radiographic principles, Indicator dilution; Blood gas analyzers: Blood pH measurement, Measurement of Blood pCO_2, pO_2 ; Plethysmography; Pacemakers(Need for Cardiac pacemaker, External pacemaker, Implantable pacemaker, Programmable pacemakers); Defibrillators(DC defibrillator, AC defibrillator and Implantable Defibrillator) , Conceptual numerical.

UNIT 3

BIOMEDICAL DEVICES FOR RESPIRATORY SYSTEMS [**7L]**

The Physiology of the Respiratory system; Tests and instrumentation for the mechanics of breathing: Lung volumes and Capacities, Mechanical measurements, instrumentation for measuring the mechanics of breathing; gas exchange and distribution: measuring of gaseous exchange and diffusion, measuring of gas distribution; Respiratory therapy equipments; Anesthesia machines: related instrumentation of equipments involved and sensors, Conceptual numericals.

UNIT 4

BIOSENSORS & BIOCHIPS [6L]

Introduction to biosensors - History and overview of Biosensors, definition and concept, components of a biosensor, consideration, commercial requirement and obstacles in biosensor development; Types of biosensors;

Biochip-Introduction and structure of DNA Chips, design and operating principles, related instruments; BIA core- an optical biosensor.

UNIT 5

APPLICATIONS OF BIOSENSORS **[10L]**

Biosensors for Health Applications: Introduction, Biosensors for diabetes applications, Biosensors for cardiovascular diseases applications, Biosensors for cancer applications. Nanobiosensor for Health Care: Nanobiosensors based on gold nanoparticles (GNPs) (Glucose biosensors, Cholesterol biosensors, Tyrosinase biosensors Urease biosensors, Acetylcholinesterase biosensors, Horseradish peroxidase). Biosensors for Environmental Applications: Introduction, Heavy metals, Biochemistry Oxygen Demand (BOD), Nitrogen compounds, PCBs, Phenolic compounds, Endocrine disruptors and hormones, Organophosphorus compounds (OP). use of biosensors for pollution control; Biosensors in aquatic and soil samples; Benefits of biosensors to bioprocess and its challenges; Electrochemical sensors, chemical fibro sensors, ion selective FETs, Micro Electromechanical sensors(MEMS) and the commercial development of biosensors,

PRIMARY REFERENCES

1. **Biomedical instrumentation and Measurements** by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Second edition, 2009
2. **Bioinstrumentation and Biosensors** by Donald L Wise, Marcel Dekker Inc. 1991
3. **Biosensors** by Cooper J.M, Oxford publication, 2004.

SECONDARY REFERENCES:

1. Hand Book of Biomedical Instrumentation by R. S. Khandpur, Second Edition, Tata McGraw- Hill, 2008

e-BOOKS

1. http://www.intechopen.com/books/biosensors-for-health-environment-and-biosecurity

2. http://www.intechopen.com/books/environmental-biosensors
3. http://www.intechopen.com/books/biosensors-emerging-materials-and-applications
4. http://www.e-booksdirectory.com/listing.php?category=366

MOOCs

1. https://www.mooc-list.com/tags/biomedical
2. https://www.class-central.com/tag/biosensors

COURSE OUTCOMES (COs)

1. Understand the components and applications of biomedical devices and biosensors.
2. Apply the characteristics of bio-signals, transducers, amplifiers and biosensors for comparing different devices used in cardio-vascular systems, respiratory systems and environment monitoring. (PO1).
3. Identify, interpret and Analyse the physical quantity measurements in electrical form using various biomedical devices and solve related problems. (PO2)
4. Design solutions for the limitations associated with existing biomedical devices and biosensors and validate the solution by applying reasoning to assess societal, health and safety issues. (PO3, PO6)
5. Work individually or in a team to identify the limitations associated with existing biomedical devices and biosensors, search for solutions and communicate the findings of the literature study and solution in the form of modified design, as oral presentations and report submission. (PO9, PO10)

VI SEMESTER SYLLABUS

Course Title	PROJECT MANAGEMENT AND FINANCE										Credits	2		
Course Code	1	9	B	T	6	H	S	P	M	F	L-T-P	2	0	0

COURSE PRE-REQUISITES: Entrepreneurship

COURSE DESCRIPTION: This course deals with planning, scheduling, organizing, and managing projects and information systems, Primary emphasis is on the project management process and tools used by professional management organizations serving manufacturing process and IT industry. Specifically, the focus is on the nine project management areas as defined by the Project Management Institute. These include project integration, scope, time, cost & cost controls, tradeoffs, quality, human resources, communications, risk, and procurement management.

COURSE OBJECTIVES: This course enables students to follow a structured approach for managing the projects.

UNIT-1

PROJECT IDENTIFICATION & FORMULATION [4 L]

Characteristics of project, Functional management, Project Life cycle & its phases, project selection process, defining the project charter, project feasibility, Roles and responsibility of project manager and team members.

UNIT-2

PROJECT PLANNING, SCHEDULING & FINANCING [7 L]

Work breakdown structure, Bar chart, Gantt chart, developing project schedule: scheduling techniques, terminologies in networking and networking convention: PERT, CPM, Sources of finance, role of financial institution in project financing, financial analysis of projects, financial risk assessment and risk mitigation planning.

UNIT-3

PROJECT EXECUTION, CO-ORDINATION & CONTROL [7L]

Communication in a project, Management Information system (MIS), cost control, crashing of network, normal time and crash time, time and cost tradeoffs, resource allocation, balance sheet, basics of agile project management.

UNIT- 4

CONTRACT, HUMAN RESOURCE MANAGEMENT & BLOCKCHAIN [4 L]

Types of contracts, sub-contracting, project organization structure, Introduction to blockchain and its applications in biotechnology, influence of blockchain in revolutionizing project management and smart contract management.

UNIT- 5

PROJECT PERFORMANCE MEASUREMENT & EVALUATION [4 L]

Termination & closeout responsibilities, performance indicators, Project post audit: phases & types, agencies for post audit.

PRIMARY REFERENCES

1. **Project Management**: S.Chodhary, Tata McGraw Hill Publication.
2. **Project Management:** K.Nagarajan, Sixth edition, New Age International Publishers.

SECONDARY REFERENCES

1. **Project Management Planning and Control Techniques:** Rory Burke, Fifth Edition, Weily India edition.

2. **Project Management The Managerial Process:** Clifford F Gray and Erik W Larson, Fifth Edition, McGraw Hill publication.
3. **Project Management for Business, Engineering and Technology:** John.M.Nicholas and Herman Steyn, Third edition, Elsevier publication.

e-BOOKS

1. http://www.free-management-ebooks.com/Principles of project management-Powl Newton &Helon Bristol

MOOCs

1. Fundamentals of Project Planning and Management (Coursera)
2. Financial Decision Rules for Project Evaluation (edX)

COURSE OUTCOMES (COs)

1. Comprehend the various aspects of project management including role of project manager.
2. Apply scheduling and financing techniques for given project to estimate project cost and duration. (PO1)
3. Analyze the performance of project by applying suitable evaluation methods (PO2)
4. Develop work breakdown structure, organization structure and construct project life cycle chart for given biotechnology process. (PO3)
5. Identify, analyze and formulate the solution for biotechnology problem applying the concepts of project management (PO3, PO11)
6. Work individually or in a team in using the project management concepts and communicate the findings as oral presentations and report submission. (PO9, PO10)

Course Title	BIOINFORMATICS										Credits	4		
Course Code	1	9	B	T	6	D	C	B	I	N	L-T-P	2	1	1

COURSE PRE-REQUISITES: Basics of computer concepts and applications, Molecular Biology, Basics of Biomolecules, Biochemistry.

COURSE DESCRIPTION: This course emphasizes on bioinformatics resources, biological databases, various bioinformatics tools and techniques to analyze and interpret the biological data. Students will be exposed to fundamentals and applications of drug design and discovery process.

COURSE OBJECTIVES: This course is designed to impart good operational knowledge on basics of bioinformatics, biological databases, various tools and techniques for the computational analysis of biological data. This course also portraits the fundamentals and applications of drug design and discovery. Further students will comprehend the importance of database and tools to generate biological data and critically analyze the results and derive valid conclusions.

PART A: THEORY

UNIT - 1 BIOINFORMATIC RESOURCES AND SEARCH TOOLS

[7L+ 1T]

Introduction to Bioinformatics, Bioinformatics resources: NCBI, EBI, ExPASy, RCSB;

Significance of databases towards informatics projects, Sequence and structure databases: GenBank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, and TrEMBL. Biomolecular sequence file formats: Gene bank flat file, Protein Data Bank (PDB) flat file, FASTA Format, PIR Format, MMDB, SCOP, Pfam. Specialized databases: OMIM, Medical databases, KEGG, EST databases.

UNIT - 2 SEQUENCE ANALYSIS

[6L+4T]

Sequence similarity search: Introduction; FASTA, BLAST, Low-Complexity Regions, Repetitive Elements. scoring matrices: Amino acid scoring matrices; PAM, BLOSUM, Comparison between PAM and BLOSUM,. Sequence Alignment: Introduction, The evolutionary basis of sequence alignment. Alignment algorithms: Pair wise alignment – Dotplot, Global alignment ,local alignment, Gaps, Gap scores and Gap penalties,

Dynamic Programming - Needleman & Wunch, Smith & Waterman, Statistical significance of Alignments. Multiple sequence alignment: Progressive pair wise methods, Iterative methods, profile based methods- PSSM; Conceptual numericals.

UNIT - 3 PHYLOGENETIC ANALYSIS AND PREDICTIVE METHODS

[6L+4T]

Introduction to Phylogenetic analysis: Tree terminologies, Forms of tree representation- Rooted and Unrooted trees; Steps in Phylogenetic data analysis; Tree building Methods: Distance based v/s character based – UPGMA, NJ, FM and Maximum likelihood, Maximum parsimony; Assessing tree reliability: Bootstrapping. Phylogenetic softwares: CLUSTALW, PAUP, PHYLIP etc. Profiles and Hidden Markov Models: PSSM. Profiles. Markov Model and HMM. Protein Motif and Domain Prediction: Identification of Motif and Domains in MSA. PROSITE. Motif and Domain Databases using Statistical Models (PRINTS, BLOCKS, ProDom, Pfam, SMART) Conceptual numericals.

UNIT - 4

ANALYTICAL TOOLS FOR GENOMIC AND PROTEOMIC STUDIES

[3L+2T]

Predictive Methods: Genomic and proteomic sequence acquisition and analysis, Web based tools; Restriction mapping: Utilities, various steps involved, Web based tools; Primer design: need for tools, Primer design tools; Structure Visualization and Graphical representation of molecular structures, Usages of visualization software available in public domain like Rasmol, Pymol,

SpdbViewer, Cn3D. Conceptual numericals.

UNIT - 5

CHEMINFORMATICS, MOLECULAR MODELING, DRUG DESIGN AND DISCOVERY [4L+2T]

Cheminformatics: Introduction, How to Represent the Molecule Structure, molecular datasets, tools and libraries, Large-Scale Data Mining ,Molecular Properties, Combinatorial chemistry. Molecular dynamics- modeling and simulations: basic concepts including force fields, protein-protein, proteinnucleic acid, protein-ligand interaction; Drug design and discovery: an overview. Role of AI in drug discovery, Protein Structure Prediction and critical Assessment, Superposition of proteins using different tools, RMSD, protein conformational analysis. QSAR. Docking and Virtual Screening. Energy Calculations (no derivation). Pharmacophore prediction based on the docking analysis.

PRIMARY REFERENCES

1. Bioinformatics- Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory, Second edition, 2004
2. Bioinformatics- A Practical Guide to the Analysis of Genes and Proteins by Andreas D Baxevanis and B.F. Francis Ouellette, A John Wiley and Sons, Second edition, 2001
3. Essentials Bioinformatics, by Jin Xiong Cambridge University Press, Second edition, 2006 **4.** Discovering Genomics, Proteomics, and Bioinformatics by A. Malcolm Campbell, Laurie J. Heyer, First edition, 2004

SECONDARY REFERENCES

1. Analytical Tools for DNA, Genes & Genomes: by Arseni Markoff, New Age, 2007
2. BIOINFORMATICS – METHODS AND APPLICATIONS: GENOMICS, PROTEOMICS AND DRUG DISCOVERY BY S C RASTOGI, N MENDIRATTA & P RASTOGI, PHI, 2006
3. BIOINFORMATICS: A biologist's guide to biocomputing and the internet. Stuart M Brown, NYU Medical Center, NY USA. 2000.

e-BOOKS

1. http://www.springer.com/in/book/9781447167013
2. http://www.e-booksdirectory.com/details.php?ebook=4481

MOOCs

1. https://www.mooc-list.com/course/bioinformatics-introduction-and-methods
2. http://nptel.ac.in/courses/102103044/40

PART B: BIOINFORMATICS LABORATORY

1. Sequence retrieval and similarity search (FASTA and BLAST) from nucleic acid and protein databases
2. Pair wise and multiple alignments of sequences – Analysis of parameters affecting alignment.
3. Evolutionary studies / Phylogenetic analysis
4. HMM construction and searches using protein database
5. Restriction site mapping and analysis.
6. Primer Design- Factors affecting primer design.
7. Assign SCOP domains to sequences using the SUPERFAMILY hidden Markov models.
8. Pattern elucidation in Proteins using PROSITE.
9. PDB Structure retrieval, Visualization and analysis of Protein Ligand interactions
10. Secondary structure prediction of proteins
11. 3D Structure prediction by Homology Modeling and Validation of modeled 3D structures – Structural analysis.
12. Superposition of structures – Calculation of RMSD and analysis.
13. Lead identification and Molecular docking.

COURSE OUTCOMES (COs)

1. Comprehend various bioinformatics resources, biological databases, file formats, sequence analysis, restriction site mapping, primer designing, visualization and drug discovery.
2. Apply the various techniques to construct sequence alignment, phylogenetic analysis, restriction site mapping, primer designing, visualization of protein structures and Insilico drug discovery. (PO5)
3. Analyse the sequence alignment, phylogenetic map to interpret the data and derive valid conclusions. (PO2)
4. Design restriction site map, primer and drug discovery through Insilico approach. (PO3)
5. Conduct experiments to perform sequence analysis, phylogenetic analysis, restriction site mapping, primer designing, visualization of protein structures, Insilico drug discovery.(PO4)

Course Title	ENZYME TECHNOLOGY & KINETICS										Credits	4		
Course Code	1	9	B	T	6	D	C	E	T	K	L-T-P	2	1	1

COURSE PRE-REQUISITES: Basics of Biomolecules, Biochemistry and Bioenergetics, Cell and Molecular Biology, and Genetic Engineering

COURSE DESCRIPTION: This course deals with one of the largest group of biomolecules what we know as enzymes. This course will cover various methods of extraction and purification of enzymes followed by activity determination. It also includes determination of kinetic parameters, various mechanism of enzyme action, immobilization techniques and effect of immobilization on the kinetic parameters and methods of creating novel enzymes.

COURSE OBJECTIVES: This course is designed to give insights on fundamentals of enzyme technology and applied biocatalysis. The course imparts knowledge on basic biochemical principles governing enzyme reactions, the mathematical models used to represent enzyme kinetics. Students will learn different types of enzyme mechanisms and applications of enzymes in medicine and industry.

PART A: THEORY

UNIT – 1

FUNDAMENTALS OF ENZYME ACTIVITY AND METHODS OF EXTRACTION PURIFICATION

[6L+2T]

Introduction and scope to enzyme science & engineering, characteristic features of enzymes, enzymes as biocatalysts, classification and nomenclature, types of enzyme specificities, Extraction of enzymes: Extraction of soluble enzymes and membrane-bound enzymes, nature of extraction medium and conditions of extraction. Purification of enzymes: preliminary and secondary purification procedures, degree of purification and criteria of purity of enzymes, uses of parameters such as specific activity, fold purification and % yield in purification, determination of molecular mass of enzymes, uses of molecular weight information, conceptual numericals.

UNIT - 2 ENZYME KINETICS

[5L+2T]

Units of enzyme activity, Enzyme kinetics, initial velocity studies, formation of ES complex, derivation of Michaelis-Menton equation, definition of K_m, V_{max}, K_{cat} and K_{cat}/K_m, Lineweaver-Burk and Eadie-Hofstee plots, deviation from hyperbolic enzyme kinetics, role of effector molecules in enzyme kinetics, effect of temperature and pH on enzyme activity. Enzyme inhibition: competitive, uncompetitive and non-competitive; Regulations – allosteric and feedback regulation. Conceptual numericals. Methods for investigating the kinetics of enzyme catalyzed reactions – Initial velocity studies, rapid-reaction techniques

UNIT - 3

BIOCATALYTIC FUNCTIONS [6L+3T]

Mechanism of enzyme action: active site, activation energy and the reaction coordinate binding energy contribution to reaction specificity and catalysis. Catalytic mechanisms: Acid-base catalysis (ribonuclease A), Covalent catalysis (chymotrypsin), Metal ion catalysis (Carbonic anhydrase), catalysis through proximity and orientation effects, Substrate strain (lysozyme) & entropy effects. Mechanism of coenzymes (NAD^+/$NADP^+$, FAD/$FADH_2$, PLP, Coenzyme A, TPP, Biotin).

UNIT - 4

ENZYME IMMOBILIZATION TECHNIQUES [4L+3T]

Immobilization of enzymes: Techniques of enzyme immobilization- physical adsorption, ionic binding, covalent binding, chelation, entrapment, encapsulation and cross-linking, kinetics of immobilized enzymes, effect of solute partition & diffusion on the kinetics, batch and continuous reactors, applications of immobilized enzymes with case studies.

UNIT - 5

ENZYME ENGINEERING [5L+3T]

Reaction engineering for enzyme-catalyzed biotransformation, biocatalysis in nonconventional media; enzymes in organic solvents, advantages of biocatalysts in organic media, biocatalysts from extreme thermophilic and hyperthermophilic microorganisms (extremozymes), artificial enzymes, catalytic antibodies, ribozymes, methods for the design and construction of novel enzymes.

PRIMARY REFERENCES

1. Fundaments of Enzymology by Nicholas C Price and Stevens Oxford Press. (1999).
2. Enzymes – Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer.
3. Biotransformations in organic synthesis by Faber.
4. Enzymes in Industry: Production and Applications by W. Gerhartz (1990), VCH Publishers, NY
5. Enzyme Technology by M.F. Chaplin and C. Bucke, CUP, Cambridge, 1990

SECONDARY REFERENCES

1. Enzyme Technology by Messing.
2. Purifying Proteins for Proteomics by Richard J Simpson, IK International, 2004 **3.** Proteins and Proteomics by Richard J Simpson, IK International, 2003
4. Enzymes by Dixon and Webb. IRL Press.
5. Principles of Enzymology for technological Applications by Butterworth Heinemann Ltd.Oxford (1993).
6. Biocatalyst for Industry by J.S. Dordrick (1991), Plenum press, New york.

e-BOOKS

1. http://trove.nla.gov.au/version/45240099
2. http://biotech.uni-greifswald.de/assets/downloads/3527304975_c01.pdf
3. http://as.wiley.com/WileyCDA/WileyTitle/productCd-3527329897.html
4. https://global.oup.com/academic/product/fundamentals-of-enzymology-9780198502296?cc=us&lang=en&

MOOCs

1. http://nptel.ac.in/courses/102102033/28

PART B: ENZYME TECHNOLOGY LABORATORY

I Isolation of enzymes

1. Isolation of amylase from germinated mung beans/sweet potato.
2. Isolation of protease from papaya or pineapple. **II**

Purification and characterization of enzymes 3.

Ammonium sulphate fractionation.

4. Purification of amylase by column chromatography (demo).
5. Determination of molecular mass of enzyme by SDS-PAGE.

III Enzyme kinetics

6. Determination of Km.
7. Effect of temperature.
8. Effect of pH.
9. Determination of specific activity.
10. Effect of inhibitors.

VI Immobilized enzymes

11. Immobilization of enzymes by gel entrapment (alginate/ carrageenan).
12. Kinetics of immobilized enzymes.

COURSE OUTCOMES (COs)

1. Select appropriate methods for isolation, purification and characterization of enzymes and solve related problems (PO1 & PO2).
2. Analyze and solve problems related to kinetics of enzymatic reactions (PO2).
3. Compare and contrast methods in enzyme catalysis and interpret the related data (PO1).
4. Illustrate immobilization techniques and their applications (PO1 & PO7).
5. Comprehend the applications of nonconventional media in enzyme catalysis and design the methods for the creation of novel enzymes (PO1 & PO3).
6. Design, conduct experiments, analyse and interpret results related to enzyme reaction kinetics (PO1, PO3, PO4 & PO7).

Course Title	GENOMICS AND PROTEOMICS										Credits	3		
Course Code	1	9	B	T	6	D	C	G	A	P	L-T-P	3	0	0

COURSE PRE-REQUISITES: Basics of Biomolecules, Biochemistry and Bioenergetics, Cell and Molecular Biology, Genetic Engineering and Bioinformatics.

COURSE DESCRIPTION: The course gives comprehensive view on the genetic organization of living organisms and contemporary high through put approaches for genome sequencing. The course also deals with high through put methods for genome, transcriptome and proteome analysis.

COURSE OBJECTIVES:

The objective of this course is to provide insights into high-throughput analysis by various methods of fundamental biomolecules such DNA, RNA and proteins. This course provides a platform to understand the networks underlying the cellular functions of living organisms.

UNIT - 1

GENOME SEQUENCING [7 L]

Genome organization, sizes and C-value paradox, need for whole genome sequencing. First generation sequencing techniques and approaches: fluorescent automated method, shot gun and clone contig approaches. Next generation sequencing technologies: steps involved in MPS. Pyro sequencing, illumina sequencing methods. Third generation sequencing: Nanopore sequencing.

UNIT - 2

GENOME MAPPING [6 L]

Need for mapping, Genetic and physical techniques for mapping: Linkage analysis, Restriction mapping-double digestion, partial digestion, optical mapping, FISH and FISH amplification in mapping, STS & EST mapping, Hybridization mapping, Sequence alignment and software packages.

UNIT - 3

GENOME ANALYSIS [10 L]

Finding genes in genomes, assigning function to new genes. Importance of non-coding sequences- micro RNAs, Sh RNAs, PiWi and RNA interference. Molecular markers: RFLPs, RAPD, AFLP, SSLP- micro and mini satellite markers, SCARS, FISH DNA amplification markers. SNPs- types, methods of analysis and applications. Methods of measurement of mRNA expression-DNA micro arrays, RNA sequencing, DDRT-PCR, Real time PCR.

UNIT - 4

QUANTITIVE PROTEOMICS [10 L]

Protein extraction, quantification, Cell-free protein production, Gel-free techniques- isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ), multidimensional protein

identification technology (MudPIT). Gel-based quantitative proteomics: Fluorescence 2-D Difference Gel Electrophoresis (DIGE), Gel-free mass spectrometry based quantitative proteomics, MALDI, and SELDI, Tandem Mass Spectrometry for Protein Identification and Peptide Mass finger printing Stable Isotope Labeling by Amino acids in Cell culture (SILAC), Isotope Coded Affinity Tag (ICAT), Isobaric Tagging for Relative and Absolute Quantitation (iTRAQ), Proteolytic labeling with [18O]-water, MS for PTM analysis, proteomic data analysis, Application of quantitative proteomics, Merits and demerits of gel-free quantitative proteomic techniques

UNIT - 5

INTERACTOMICS [6 L]

Techniques to study protein-protein Interactions (Yeast Two-Hybrid (YTH), Immunoprecipitation (IP), Protein microarrays (Abundance-based microarrays and function-based microarrays), Protein-protein interactions to understand biological Systems, pros and cons of using various interactomics techniques, **Label-free nanotechnologies in proteomics:**

Surface Plasmon Resonance (SPR), Atomic Force Microscopy (AFM), carbon nanotubes & nanowires, Electrochemical Impedance Spectroscopy (EIS), MEMS cantilevers.

PRIMARY REFERENCES

1. Genomes by Brown T A, 2006, Fifth edition, Blackwell Science
2. Gene Cloning & DNA Analysis: An Introduction by Brown T A, 2006, Fifth edition, Blackwell Science.
3. Introduction to Proteomics: Tools for the New Biology, D.C. Liebler, Humana Press, 2002.
4. Proteomics: From Protein Sequence to Function, S. R. Pennington, Michael J. Dunn. Garland Science,
5. Principles of Proteomics, R.M. Twyman, Bios Scientific Pub., 2004.

SECONDARY REFERENCES

1. A Primer of Genome Science by Greg Gibson and Spencer V, Third Edition, Muse,February 2009

2. Proteomics in Practice: A Guide to Successful Experimental Design, R. Westermeier, T. Naven, H-R. HÃ¶pker, Wiley-VCH, 2008.

e-BOOKS

1. Genomes by Brown T A, 2006, Fifth edition, Blackwell Science
2. Principles of gene manipulation by S. B. Primrose, Richard M. Twyman, R. W. Old – 2001.

MOOCs

1. http://www.nptel.ac.in/courses/102103017/30
2. http://www.nptel.ac.in/syllabus/102101007/

COURSE OUTCOMES (COs)

1. Select and describe techniques and approaches for genome sequencing. Analyze and interpret related data (PO1, 5, 12).
2. Select and describe applications of various contemporary genome mapping techniques as well as interpret related data (PO1, 5, 12).
3. Select and describe applications of contemporary high-throughput techniques for analysis of genomes, transcriptomes and Proteomes. (PO 5, 12).
4. Differentiate the application of contemporary high-throughput techniques for protein protein interaction studies.(PO1,12)

DEPARTMENT OF BIOTECHNOLOGY

Course Title	SEMINAR													
Course Code	1	9	B	T	6	D	C	S	E	M	Credits	01	L – T – P	0 – 0– 0
CIE	100 marks (50% weightage)										SEE		100 marks (50% weightage)	

COURSE PRE-REQUISITES: Knowledge of chemistry, physics Mathematics and Basics of Biology.

COURSE DESCRIPTION: Student need to present seminar based on the hands work experience or internship work during winter/summer break or SWAYAM/NPTEL/MOOC courses.

COURSE OBJECTIVES: This course will help students be aware of the current trends in the field of Biotechnology

PO	(CO) COURSE OUTCOMES	Descriptor
PO1	CO1	Survey literature pertaining to given topic
PO4	CO2	Conduct and design experiments
PO10	CO3	Write effective report and present effectively by oral communication
PO9	CO4	Ability to work individually or team.

DEPARTMENT OF BIOTECHNOLOGY

Course Title	MULTIDISCIPLINARY PROJECT 2										Credits	2		
Course Code	1	9	B	T	6	D	C	P	R	W	L-T-P	3	0	0

COURSE PRE-REQUISITES: Engineering Physics, Engineering Chemistry, Engineering Mathematics and all other subjects of the previous semesters related to the multidisciplinary project.

COURSE DESCRIPTION:

The field of biotechnology has become more quantitative and interdisciplinary as research in biotechnology continues to grow at a tremendous rate with broader and complex applications in medicine, agriculture, the environment and nanobiotechnology. As biological concepts and models become more quantitative, biological research will be increasingly dependent on concepts and methods drawn from other scientific disciplines. Therefore, in order to prepare our undergraduate life science students to be future research scientists, we need to transform undergraduate education. This will require life science majors to develop and reinforce connections between biology and other scientific disciplines so that interdisciplinary thinking and work becomes second nature.

The students are expected to further continue their work on the previous semester multidisciplinary project based around real-world open problems involving both biological as well engineering aspects of Biotechnology and are required to explore biological systems to develop new technologies, tools and products that are useful in research, industry and agriculture.

The aim of the course is to train the student to working in a multidisciplinary project based development work, in which the student is expected to acquire knowledge on project by designing and conducting experiments independently in a group within a given period of time and present the same.

COURSE OBJECTIVES:

1. To develop a creative attitude to the development and manufacture of biotechnology products using multidisciplinary approach.
2. To train leadership and teamwork via the multidisciplinary project.
3. To prepare the students for industry as well as research programs by imparting professional skills development.

COURSE OUTCOMES

1. Design and conduct preliminary experiments independently in a group within a given period of time.
2. Write effective report and communicate effectively by oral presentation.

	COURSE: MULTIDISCIPLINARY PROJECT CODE: 19BT5DCPRW											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			2	3	3				3		2	
CO2										3		

Course Title	HEALTH AND NUTRITION										Credits	3		
Course Code	1	9	B	T	6	O	E	H	A	N	L-T-P	3	0	0

PRE-REQUISITES:

Knowledge of Engineering Chemistry and Biology for Engineers.

COURSE DESCRIPTION:

This course deals with the basics of health and nutrition of humans. The course emphasizes on importance basic food nutrients in one's sustainable life. The course provide in depth knowldeg about nutritional intake, dietary standards and food substitutes.

COURSE OBJECTIVES: To enable the students to gain knowledge on the various aspects of food nutrients, their intake and deficiency disorders.

UNIT1 INTRODUCTION TO HUMAN NUTRITION [10 L]

A Global Perspective on Food and Nutrition, Orientation to human nutrition, An integrated approach, A conceptional framework for the study of nutrition, Relationship between nutrition and health, Nutrients: the basics: carbohydrates, lipids and proteins; Connections of Carbohydrate, Protein, and Lipid Metabolism in single Pathway; Global malnutrition, Anorexia, obesity. Relationship between nutrition science and practice, Nutrition milestones: the development of nutrition as a science, Future challenges for nutrition research and practice.

UNIT2

BODY COMPOSITION & DIETARY REFERENCE STANDARDS [07L]

Introduction, Five levels of body composition, Relationships between different levels of body composition, Body composition techniques : Direct and indirect methods;

Terminology and conceptual approaches to setting nutrient recommendations, Interpretation and uses of dietary recommendations, The use of reference values to assess the adequacy of the nutrient intakes of population groups, Methods used to determine requirements and set dietary recommendations, Methods used to determine requirements,

UNIT 3

ESSENTIAL NUTRIENTS [06 L]

Vitamins: Introduction, classification, Dietary sources, uses and disorders; Minerals and Trace Elements: Introduction, classification, Dietary sources, uses and disorders;

UNIT 4

FOOD SUBSTITUTES : NATURAL VS ARTIFICIAL [06 L]

Nutritive and Non-Nutritive Sweeteners : Classification, uses, and impact; Food flavours: Classification, uses, and impact; Food colours: Classification, uses, and impact;

UNIT 5

SOCIETAL FOOD HABITS [10 hrs]

Studying food habits, Who chooses? Social and cultural influences on food choice, Food habits in nutrition practice, Changing food habits in the modern world; Nutritional recommendations for the general population : Recommended nutrient intakes, A lower diagnostic level for assessing adequacy of nutrient intake, An upper level (UL) to control high dosage of supplements, Estimated average requirement (EAR), Optimal intake range for some essential nutrients, Dietary goals and guidelines (DGGs), Dietary guidelines for children,WHO guide lines, Can recommended nutrient intakes and dietary goals be combined? Dietary goals and guidelines in developing countries, Integrating RNIs and DGGs in nutrition promotion, Reference numbers for nutrition labelling and food standards.

PRIMARY REFERENCE BOOKS:

1. **Introduction to human nutrition by** Michael J Gibney, Susan A Lanham-New, Aedin Cassidy, Hester H Vorster, Second edition, Wiley Blackwell, 2009.
2. **Essentials of Human Nutrition**, by Jim Mann, A. Stewart Truswell, second edition,Oxford university press, 2002

SECONDARY REFERENCE BOOKS:

1. **Principles of Human Nutrition** by Martin Eastwood Edinburgh, second edition, Blackwell Science Ltd, 2003.

e-books:

2. http://faculty.sdmiramar.edu/faculty/sdccd/mmcmahon/nutrition/
3. http://www.freebookcentre.net/medical_books_download/Nutrition-in-Health-andDiseases.html
4. http://www.freebookcentre.net/medical_books_download/The-Chemistry-of-Food-andNutrition.html

Moocs:

5. https://www.mooc-list.com/categories/food-nutrition
6. https://www.mooc-list.com/tags/nutrition
7. https://www.my-mooc.com/en/mooc/nutrition-health-part-1-macronutrients-wageningenxnutr101x-0/

8. https://www.edx.org/course/subject/food-nutrition **Course Outcomes:**

1. Understand the components of basic food nutrients and their uses.
2. Apply various techniques to determine bodily composition of nutrients and impact of essential food substituents.
3. Analyse the nature of food habits and intake, societal behaviour towards food and artificial food substitutes.
4. Communicate individually or in a team to identify and asses the case studies relevant to food habits and challenges across the globe.

Course Title	ALTERNATIVE ENERGY										Credits	3		
Course Code	1	9	B	T	6	O	E	A	T	E	L-T-P	3	0	0

PRE-REQUISITES:

Knowledge of Engineering Chemistry, Basic Electrical Engineering, Elements of Electronics Engineering and Biology for Engineers.

COURSE DESCRIPTION: The course emphasise on solar energy and its radiation, collection, storage and application. The course also introduces the Wind, Tidal, Geothermal and Bio energy, as alternative energy sources.

COURSE OBJECTIVES: To enable the students to gain knowledge on the various resources of alternative energy and its applications.

UNIT 1

Energy Scenario [06 L]

Forms of energy, units for energy measurement, classification of energy resources, energy and environment, energy consumption pattern, energy requirement - current scenario, problems with conventional energy, alternative energy resources-a global solution to energy requirement?

UNIT 2

WAVE AND TIDAL ENERGY [07 L]

Wave energy: introduction, wave motion, wave energy energy and power, real sea waves, energy extraction from devices, wave power devices, social economic and environmental aspects.

Tidal energy: introduction, the cause of tides, enhancement of tides, tidal current/stream power, tidal range power, social and environmental aspects.

UNIT 3

BIOMASS AND BIOFUELS [10 L]

Introduction, Biofuel classification, Biomass production for energy farming, Direct combustion for heat, Pyrolysis (destructive distillation), Further thermochemical processes, Alcoholic fermentation, Anaerobic digestion for biogas :Introduction, Types of biogas digesters, Working digesters , Wastes and residues, Vegetable oils and biodiesel, Social and environmental aspects.

UNIT 4

WIND ENERGY **[06 L]**

Wind energy, Wind generation, History of wind energy applications, Wind energy characteristics, Wind characteristics, Modern wind turbines: Wind turbine classification, Wind turbine configuration, Wind power parameters, Wind turbine controls; Challenges in wind power generation, Trends in wind turbine developments and wind power generation.

UNIT 5

SOLAR AND GEOTHERMAL ENERGY [10 L]

Solar Energy: Introduction, The rapidly changing world of solar energy, Solar electricity and solar heating, Solar electricity and solar heating, The principles of solar electricity, Solar as supplementary and only source of electricity, Why choose a solar electric system?, Components of a Solar Electric System(in brief)

Solar radiation and its measurements: solar constant, solar radiation at the Earth's surface, solar radiation geometry, Solar radiation measurements, solar radiation on tilted surfaces; Solar energy collectors: physical principles of the conversion of solar radiation into heat, flat plate collectors, concentrating collectors; Solar energy storage systems, application of solar energy.

Geothermal energy: Origin and distribution, geothermal resources: types, analysis, exploration and development; Environmental considerations, Applications.

PRIMARY REFERENCE BOOKS:

1. **Non-conventional energy sources** by G. D. Rai, Khanna Publishers, 6th edition, 2017.
2. **Non-conventional energy resources** by B H Khan, Tata McGraw Hill, 2nd edition, 2009.
3. **Renewable energy resources** by John Twidell and Tony Weir, 3rd edition, Taylor and Francis group, 2015.

SECONDARY REFERENCE BOOKS:

1. **Fundamentals of wind energy by Wei Tong,** WIT Transactions on State of the Art in Science and Engineering, Vol 44, WIT Press, 2010.
2. **Renewable energy resources** by John Twidell and Tony Weir, 2nd edition, Taylor and Francis group, 2006.

e-books:

1. https://www.elsevier.com/books/renewable-energy/sorensen/978-0-12-375025-9
2. https://www.springer.com/gp/book/9789400714014

Moocs:

1. https://www.edx.org/course/energy-principles-and-renewable-energy
2. https://www.edx.org/course/solar-energy-integration-of-photovoltaic-systems-i

Course Outcomes:

1. Understand the principles of operation of the broad spectrum of renewable energy technologies.
2. Conduct preliminary resource assessments for a variety of renewable energy technologies.
3. Analyse energy technologies from a systems perspective and articulate the technical challenges for each of the renewable sources.
4. Review the literature related to the renewable energy and present individually or in a team.

Course Title	ANIMAL BIOTECHNOLOGY										Credits	3		
Course Code	1	9	B	T	6	D	E3	A	B	T	L-T-P	3	0	0

COURSE PRE-REQUISITES: Cell and Molecular Biology, Human Physiology, Basics of Biomolecules , Biochemistry and Bioenergetics, Bio analytical Techniques, Immunotechnology and Genetic Engg.

COURSE DESCRIPTION: This course includes the history of Animal biotechnology, development and maintenance of animal cell, tissue and organ cultures. It also includes the latest advances in tissue culture techniques and the regulatory guidelines for animal cell culture.

COURSE OBJECTIVES: To empower graduates to understand current technologies applied in Animal cell culture and its applications

UNIT- 1

INTRODUCTION TO ANIMAL CELL CULTURE [5 L]

History, scope, advantages & limitations. Planning, Construction, layout of laboratory.

UNIT-2

ESSENTIALS FOR ANIMAL CELL CULTURE [7 L]

Essential equipment and culture Vessels (types & designs).: Media and reagents Physicochemical properties, Balanced salt solutions, complete media, Serum, serum free media, MEM, DMEM, RPMI and Ham's medium, role of antibiotics in media. Principles of sterile techniques.

UNIT -3

ANIMAL CELL CULTURE TECHNIQUES [7 L]

Establishment of primary cell cultures and cell lines, nomenclature, subculture, propagation and maintenance, suspension cultures & anchorage dependent cultures, Development and maintenance of Embryonic & adult stem cells, Organ and organotypic cultures, Contamination: Sources, types, Monitoring and Eradication, cryopreservation.

UNIT - 4

CHARACTERIZATION OF CELL LINES AND TISSUES [10 L]

Behavior ,morphology, growth characteristics, chromosome analysis, DNA, RNA and Protein Content, Enzyme and Antigenic Markers, Transformation, Immortalization, Aberrant Growth Control, Tumorigenicity, Cell counting, Plating Efficiency, Labeling Index, Generation Time. Cytotoxicity assays: Viability and Survival assays, Micro-titration and Transformation assays.

UNIT - 5

APPLICATIONS [10 L]

Gene mapping, marker assisted selection and genetic improvement of desired characters of domestic animals, Commercial scale production of animal cells,

Applications of animal cells: in-vitro testing of drugs and environmental pollutants, production of vaccines, growth factors and pharmaceutical proteins. Transgenic animals as bioreactors for production of proteins of pharmaceutical value. Ethical & legal issues

PRIMARY REFERENCES

1. Culture of Animal Cells by Freshney R I(2005), 5th Edn, Wiley-Liss.

2. Animal Cell Biotechnology by Spier RE and Griffiths JB (1988), Academic Press.6th edn.

SECONDARY REFERENCES

1. Molecular Biotechnology: Principles and Practices by Channarayappa (2006). University Press (India) Pvt.Ltd., Worldwide CRC Press,1st edn.

2. Molecular Biotechnology by Primrose; Blackwell scientific publication, 2nd edition

3. Animal Biotechnology by Murray Moo- Young (1989), Pergamon Press, Oxford, 1st edition

4. Introduction to cell & tissue culture by Jennie P. Mather & P.E.Robert, Springer-1st edition

e-BOOKS

1. Animal Cell Biotechnology Methods and Protocols, Editors: Nigel; ISBN: 978-0-89603-547-8(Print) 978-1-59259-486-3(Online), http://link.springer.com/book/10.1385%2F0896035476

2. Animal Biotechnology, 1st Edition Models in Discovery and Translation Editor(s):Verma & Singh eBook ISBN :9780123914347, http://store.elsevier.com/Animal-Biotechnology/isbn9780124160026/

MOOCs

1. http://ocw.mit.edu (http://ocw.mit.edu/courses/biology/7-342-developmental-and-molecularbiology-of-regeneration-spring-2008/#)

COURSE OUTCOMES (COs)

1. Draw sketches for layouts to design cell culture labs, (PO1, 3)
2. select and relate the usage of suitable equipment and media. (PO1, 3)
3. Differentiate the methods used for characterization of cultured cells. (PO1)
4. Relate the potential applications and merits & demerits of transgenic technologies in health and disease.(PO5,6, 12)
5. Select and describe the methodologies used for commercial scale production of animal cells and their products. (PO1,12)

DEPARTMENT OF BIOTECHNOLOGY

Course Title	PROCESS CONTROL & AUTOMATION										Credits	3		
Course Code	1	9	B	T	6	D	E3	P	C	A	L-T-P	3	0	0

COURSE PRE-REQUISITES: Engineering Mathematics, Unit Operations 1, Unit Operations 2, Reaction Engineering

COURSE DESCRIPTION: This course provides basic knowledge of process control in first and second order systems. It also deals with various types of controllers and final control elements in process control. The course describes criterion for stability of a given system and basic concepts of automation.

COURSE OBJECTIVES: This course will enable students to understand the concepts of process parameter control and analyze the closed loop and open loop control system. They will be able to carry out the stability analysis for a given biochemical process.

UNIT - 1

INTRODUCTION TO BIOPROCESS CONTROL **[5 L]**

Typical Industrial Control Problem – Stirred Tank Heater. Variables of a Process, Concept of process Control System, Overview of Control System Design, Laplace transforms, conceptual numericals.

UNIT - 2

FIRST ORDER SYSTEMS **[9 L]**

First order systems – examples, mercury in glass thermometer, liquid level system, linearization, response of first order system for step, pulse, impulse and sinusoidal changes in input, conceptual numericals. First order systems in series- Interacting and non-interacting systems and their dynamic response to step, pulse and impulse inputs; conceptual numericals.

UNIT – 3

SECOND ORDER SYSTEMS [7 L]

Second order systems with transfer functions (spring-damper, control valve, U-tube manometer), response of second order system to step, pulse / impulse and sinusoidal input – Over damped, under damped and critically damped condition of second order system, transportation lag, conceptual numericals.

UNIT - 4

CLOSED LOOP CONTROL SYSTEMS [10 L]

Block diagrams for servo and regulatory problems. Transient response of first and second order processes for set point changes and load changes with proportional and PI controllers, conceptual numericals. Controllers and final control elements - Actuators, Positioners, Valve body, Valve plugs,

Characteristics of final control elements, controllers –proportional control, derivative control, integral control, P-I (proportional-integral) control, P-D (proportional- derivative) control, P-I-D (proportional-integral-derivative) control, conceptual numericals.

UNIT - 5

BIOPROCESS DYNAMICS, STABILTY AND AUTOMATION [8 L]

Criteria for stability, Routh test; Root locus (basics) - Conceptual numericals; Introduction to frequency response, Bode criteria for stability, Nyquist criteria;. Dynamics and control of bioreactors & sterilizers. On-line data analysis for state and parameter estimation techniques for biochemical processes, basics of industrial automation systems: PLCs, SCADA and Distributed control systems (DCS), their features and applications.

PRIMARY REFERENCES

1. Process System analysis and Control by Donald R Coughanowr, 2nd Edition,. McGraw-Hill, 1991
2. Chemical Process Control by George Stephanopoulos, Prentice-Hall of India, 1999.

SECONDARY REFERENCES

1. Process dynamics and control by D E Seborg, T F Edger, John Wiley, 1989
2. Essentials of Process Control by Luyben and Luyben.
3. Process Modeling, Simulation and Control by William Luyben.
4. Biochemical Engineering Fundamentals by Bailey and Ollis, Mcgraw Hill (2nd Ed.). 1986.
5. Bioprocess Engineering by Shuler and Kargi Prentice Hall, 1992.
6. Bioprocess Engineering Principles by Pauline M. Doran, 1995.

e-BOOKS

1. https://udghoshna.files.wordpress.com/2013/06/136649035-process-systems-analysis-andcontrol-d-coughanowr-3rd-ed.pdf
2. http://44book.blogspot.in/2015/09/chemical-process-control-stephanopoulos.html

MOOCs

1. https://onlinecourses.nptel.ac.in/noc16_ee02/preview
2. http://ocw.mit.edu/courses/chemical-engineering/10-450-process-dynamics-operationsand-control-spring-2006/

COURSE OUTCOMES (COs)

1. Comprehend the components of automatic process control systems, characteristics of Laplace Transform and working principle of various controllers and final control elements.
2. Apply Laplace transform to deduce transfer function for various systems. (PO1)
3. Identify, interpret and analyse the response and stability of a given process control system and solve related problems. (PO2)
4. Apply tools to design and interpret responses for a given physical system. (PO3, PO5)
5. Work individually or in a team in using the tools and communicate the findings as oral presentations and report submission. (PO9, PO10)

Course Title		SIGNAL TRANSDUCTION									Credits	3		
Course Code	1	9	B	T	6	D	E 3	S	T	N	L-T-P	3	0	0

COURSE PRE-REQUISITES : Cell And Molecular Biology, Human Physiology, Basics Of Biomolecules and Immunotechnology

COURSE DESCRIPTION: This course gives a comprehensive Account of Cell Signaling and Signal Transduction. It explains the biochemical basis of the transmission of molecular signals from a cell`s exterior to its interior and how these can affect cellular behavior and gene expression. It also gives an overview of cell signaling w.r.t tumor biology

COURSE OBJECTIVES: The course aims to give a basic knowledge of mechanisms of signal transduction and the significance of signal transduction in physiology and pathophysiology.

UNIT - 1

SIGNAL TRANSDUCTION [9 L]

Signal Transduction: Definition, Signals, Ligands and Receptors. Endocrine, Paracrine and Autocrine Signaling.

Sensory Transduction : Nerve Impulse Transmission – Nerve Cells, Synapses, Reflex Arc Structure, Resting Membrane Potential, Nernst Equation, Action Potential, Voltage Gated Ion-Channels, Impulse Transmission, Neurotransmitters, Neurotransmitter Receptors.

Rod And Cone Cells In The Retina, Biochemical Changes In The Visual Cycle, Photochemical Reaction And Regulation Of Rhodopsin. Odor Receptors.

UNIT - 2

RECEPTORS AND SIGNALING PATHWAYS [9 L]

Cell Signaling, Cell Surface Receptors. G Protein Coupled Receptors- Structure, Mechanism Of Signal Transmission, Regulatory Gtpases, Heterotrimeric G Proteins And Effector Molecules Of G Proteins. Signaling Molecules-Camp, Cgmp, Metabolic Pathways For The Formation Of Inositol Triphosphate From Phosphatidyl Inositol Diphosphate, Ca2+, DAG And NO As Signaling Molecules, Ryanodine And Other Ca2+ Receptors, Phospho-Regulation Of Inositol And The Calcium Channel Activation. Ser/Thr-Specific Protein Kinases and Phosphatases. Receptor Tyrosine Kinases, Role of Phosphotyrosine in SH2 Domain Binding. Signal Transmission via Ras Proteins and MAP Kinase Pathway

UNIT - 3

SIGNALING RECEPTORS [7 L]

Signaling By Nuclear Receptors: Ligands, Structure and Functions of Nuclear Receptors, Nuclear Functions for Hormones/Metabolites - Orphan Receptors; Cytoplasmic Functions and Crosstalk with Signaling Molecules, Signaling Pathway of the Steroid Hormone Receptors. Cytokine Receptors- Structure and Activation of Cytokine Receptors, Jak-Stat Path Way, Janus Kinases, Stat Proteins.

UNIT - 4

REGULATION OF THE CELL CYCLE [7 L]

Overview Of The Cell Cycle, Cell Cycle Control Mechanisms, Cyclin-Dependent Protein Kinases (Cdks), Regulation Of Cell Cycle By Proteolysis, G1/S Phase Transition, G2/M Phase Transition, Cell Cycle Control Of DNA Replication, DNA Damage Check Points.

UNIT - 5

SIGNAL TRANSDUCTION IN HEALTH AND DISEASE [7 L]

Errors in Function of Signal Proteins And Tumorigenesis. Oncogenes, Proto-Oncogenes and Tumor Suppressor Genes. Tumor Suppressor Protein P53 and Its Role in Tumor Suppression. Tumor Suppressor APC and Wnt/□-Catenin Signaling. Current Research in Oncogenes And Suppressor Genes, Recent Scenario Of Signaling Pathways In Interleukins And Cell Surface Receptors.

PRIMARY REFERENCES

1. Molecular Biology- David Freifelder, Narosa Publishing House Pvt. Limited, 2005
2. Biochemistry Of Signal Transduction And Regulation. 3rd Edition. Gerhard Krauss, 2003 WILEY-VCH Verlag Gmbh & Co. Kgaa, Weinheim ISBN: 3-527-30591-2
3. Molecular Biology Of The Cell, 4th Edition, Bruce Alberts. New York: Garland Science; 2002. ISBN-10: 0-8153-3218-1ISBN-10: 0-8153-4072-9

SECONDARY REFERENCES

1. Molecular Cell Biology, 4th Edition**,** Harvey Lodish.New York: W. H. Freeman; 2000. ISBN-10: 0-7167-3136-3
2. Principles Of Cell And Molecular Biology- Lewis Kleinsmith, 2nd Edition, Illustrated, Harpercollins, 1995.

e-BOOKS

1. Biochemistry of Signal Transduction and Regulation, Second EditionAuthor(s): Gerhard KraussFirst published:17 July 2001Print ISBN:9783527303786 |Online

   SBN:9783527600052 |DOI:10.1002/3527600051Copyright © 2001 Wiley-VCH Verlag GmbH

2. Biochemistry, 5th editionJeremy M Berg, John L Tymoczko, and Lubert Stryer. New York: W H Freeman; 2002.ISBN-10: 0-7167-3051-0
   https://www.ncbi.nlm.nih.gov/books/NBK21154/

MOOCs

1. https://Www.Open.Edu/Openlearn/Science-Maths-Technology/Cell-Signalling/ContentSection-0?Active-Tab=Description-Tab

COURSE OUTCOMES (COs)

1. Elucidate the basic principles of signal transduction mechanisms in heath and disease (PO1)
2. Identify the different types of Extracellular/intracellular Signals And Receptors and correlate to their functional significance in heath and disease (PO 2)
3. Design the mechanisms by which different receptors may be regulated by ligands (PO 3.PO 5 &PO 12)

DEPARTMENT OF BIOTECHNOLOGY

Course Title	FOOD BIOTECHNOLOGY										Credits	3		
Course Code	1	9	B	T	6	D	E4	F	B	T	L-T-P	3	0	0

COURSE PRE-REQUISITES: Basics of biology, Microbiology, Biochemistry, Basics of biomolecules and Genetic engineering.

COURSE OBJECTIVES: This course enables the students to understand the characteristics food products, microbial contamination of food & impact on food quality and application of biotechnological approaches for sustainable food production. The course also emphasize on major fermented food products and their production.

UNIT 1 MAJOR FOOD PARAMETERS AND FOOD EVALUATION [7 L]

Colloidal Systems in Food and its Stability, Types of Food Starches, Soluble Fibres (Pectins, Gums, Mucilages), Factors leading to Rancidity and Reversion, Prevention of rancidity, Aroma Compounds in Foods (monosodium glutamate, nucleotides), Food Flavours, Browning Reactions, Sugar substitutes (sorbitol. Sweeteners-saccharin, cyclamate), Food colours, Anti-nutritional factors, Food rheology: Properties of Fluid, Solid and Granular Foods and Powders. Measurement of Rheological

Parameters and Food Texture. Food Evaluation: Objectives of food processing, Subjective and

Objective evaluation (viscosity, density,

UNIT - 2 FOOD INDUSTRY AND BIOTECHNOLOGY [10 L]

Nutraceuticals: Definition, types and importance. Role of biotechnology in improvement of nutraceuticals (bio fortification) - Probiotics, essential minerals, amino acids, proteins, vitamins, flavonoids and anti-oxidants. Enzymes in food industry: Sachharification (ezymes involved principle of starch processing and uses), Pectinases in juice clarification and lipases in fat processing. Immobilized Enzymes in Food Industry: Properties and uses. GM food crops: Corn, Alfa alfa, Sugar beet, Soybean, Canola and Brinjal. Economic, Regulatory and Social aspects of biotechnologicallyprocessed foods. HACCP: guidance and regulation for food and dietary supplements. FSSAI: Food safety regulation in context to India

UNIT - 3 FOOD MICROBIOLOGY [7 L]

Primary Sources and factors affecting microorganisms found in Foods. Microbial spoilage: Synopsis of Common Food-borne bacteria Molds and Yeasts. Spoilage of Vegetables and Fruits, Fresh and Processed Meats, Poultry and Seafood (microbes involved and chemical changes caused). Microbiological analysis of foods: Advanced culturing methods for rapid detection (RODAC, Petrifilm, Use of selective and differential media, and Enumeration of selective organisms). Examination of surfaces: Air Sampling (passive and active sampling). Biochemical (ATP bioluminescence, DEFT, Flow cytometry) and Molecular methods (FISH, PCR-based genotyping,

MDMs and PFGE) for rapid detection.

UNIT - 4 FOOD PRESERVATION [10 L]

Food Preservation using irradiation: Characteristics of Radiations of Interest in Food Preservation,

Principles Underlying Food Preservation by Irradiation, Processing of Foods for Irradiation, Effect of Irradiation on Food constituents, Legal Status of Food Irradiation, Thermal Properties of Frozen

Foods, Prediction of Freezing Rates: Qualitative Explanation via Plank's Equation, Neumann Problem and Tao Solution, Food Freezing Equipments: Air Blast Freezers, Plate Freezers and Immersion Freezers, Food Dehydration: Estimation of Drying Time, Constant Rate Period and Falling Rate Period Dehydration, Equipments: Fixed Tray Dehydration, Cabinet Drying, Tunnel Drying. Freeze Dehydration, Calculation of Drying Times.

UNIT - 5 PROCESSED FOOD PRODUCTS [6 L]

Microbial Transformations: Milk products (Cheese, sankerfrakt, yoghurt manufacture and flavours; Fruit juices, beverages, pickles, sauces, jams & jellies.

PRIMARY REFERENCES

1. **Modern Food Micro-Biology**: James M.Jay, (2005), CBS Publishers.
2. **Food Science & Nutrition**: Suneta Roday, Oxford University Press, 2007.
3. **Food Science:** Norman.N.Potter and Joseph.H.Hotchkiss, Aspen publication, 5th edition.

SECONDARY REFERENCES

1. **Food Microbiology:** William C Frazier, Dennis C Westhoff, 5th Edition, Mc Graw Hill Publishers. 2015
2. **Introduction to Food Engineering:** R. Paul Singh, Dennis R. Heldman, Amsterdam [u.a.]: Elsevier, 2007.

e-BOOKS

1. Applications of Biotechnology in Traditional Fermented Foods. By 'Panel on the Applications of Biotechnology to Traditional Fermented Foods, National Research Council'

2. Food Microbiology (Sie) by Frazier,Tata McGraw-Hill Education, 1987
3. Modern Food Micro-Biology: James M.Jay, (2005), CBS Publishers.

MOOCs

1. Food Security and Sustainability:Crop production(edX) https://www.mooclist.com/course/food-security-and-sustainability-crop-production-edx?static=true

2. Nutrition and Health Part 3: Food Safety (edX). https://www.mooc-list.com/course/nutritionand-health-part-3-food-safety-edx?static=true

Course Title	GENOME INFORMATICS										Credits	3		
Course Code	1	9	B	T	6	D	E4	G	I	N	L-T-P	3	0	0

COURSE PRE-REQUISITES: Biostatistics and probability, Basics of Computer applications, Cell and Molecular Biology, Genetic Engineering, Bioinformatics and Genomics & Proteomics.

COURSE DESCRIPTION: This course emphasizes on various next-generation sequencing techniques, assembling the sequencing data, de Novo assembling algorithms for assembly and visualization of sequence data. The course also includes applications of NGS in cancer and other diseases.

COURSE OBJECTIVES: This course is designed to impart good operational knowledge of various next-generation sequencing tools and algorithms for sequencing, assembling, analysing and visualizing the sequence data. Further students will comprehend the importance of NGS in cancer and other diseases.

UNIT – 1

EMERGENCE OF NEXT-GENERATION SEQUENCING [9 L]

Pyrosequencing; Illumina (Solexa) Genome Analyzer; Applied Biosystems SOLiD; Ion Semiconductor (Ion Torrent Sequencing); Polonator Technology, Heliscope (Single Molecule Sequencing), Latest Developments in Next-Generation Sequencing Methods: Nanopore Sequencing, Single Molecule Real Time DNA Sequencing ; Comparison of Next-Generation Sequencing Techniques; Sequencing Status; Shortcoming of NGS Techniques: Short-Reads and Reads Accuracy Issues, NGS File Formats.

UNIT – 2

THE ASSEMBLY OF SEQUENCING DATA [6 L]

De Novo Genome Sequence Assembly; Challenges of Genome Assembly; Use of Paired-End

Reads in the Assembly; Data Pre-processing Methods and Sequence Read Correction Methods; Assembly Errors; Evaluation of Assembly Methods; NGS Data Visualization using Genome Browsers – UCSC and Ensemble genome browsers.

UNIT - 3

DE NOVO ASSEMBLY ALGORITHMS [7 L]

Mapping Assembly to a Graph Problem, The Overlap Graph Approach; De Bruijn Graph Approach; Classification of De Novo Assembly Algorithms; Greedy Algorithms; Overlap Layout Consensus (OLC) Algorithms; De Bruijn Graph-Based Algorithms; Comparison of Algorithms; Working methodologies with NGS data: Data acquisition, Quality check, Trimming, Assembly, Mapping and Visualization.

UNIT – 4

NEXT GENERATION SEQUENCING IN CANCER RESEARCH [10 L]

Applications of NGS in RNA biomarker discovery in cancer research; Role of long non coding RNAs in cancer genome; NGS for high-throughput RNA interference screens; RNAseq in prostate cancer research; cancer genomics and cancer epigenomics; Targeted sequencing strategies; MicroRNAs and cancer.

UNIT – 5

NEXT GENERATION SEQUENCING IN CLINICAL RESEARCH [7 L]

Neuropsychiatric and Neuroinflammatory Disorders : Polymorphisms in Major Depressive Disorders; Polymorphisms in ADHD; Polymorphisms in Neuroinflammatory Diseases; Multiple Sclerosis; Alzheimer's Disease; Parkinson's Disease; Role of the NGS in Early Diagnostic and Treatment.

PRIMARY REFERENCES

1. Ali Masoudi-Nejad, Zahra Narimani, Nazanin Hosseinkhan; "Next Generation Sequencing and Sequence Assembly", Methodologies and Algorithms, Springer; 2013.
2. Mark I. Rees, "Challenges and Opportunities of Next-generation Sequencing for Biomedical Research", Academic Press, 2012.
3. Wu, Wei, Choudhry, Hani (Eds.), "Next Generation Sequencing in Cancer Research: Volume 1: Decoding the Cancer Genome", Springer, 2013.

SECONDARY REFERENCES

1. Genomes by Brown T A, 2006, Fifth edition, Blackwell Science
2. A Primer of Genome Science by Greg Gibson and Spencer V, Third Edition, Muse,February 2009

e-BOOKS

1. http://www.springer.com/us/book/9781461477259
2. http://store.elsevier.com/Challenges-and-Opportunities-of-Next-Generation-Sequencingfor-Biomedical-Research/isbn-9780123942876/
3. http://vufind.carli.illinois.edu/vf-rou/Record/rou_279168/TOC

MOOCs

1. https://www.mooc-list.com/course/clinical-bioinformatics-unlocking-genomics-healthcarefuturelearn?static=true
2. https://www.mooc-list.com/tags/next-generation-sequencing?static=true

COURSE OUTCOMES (COs)

1. Comprehend and compare various Next-Generation Sequencing Techniques.
2. Apply the tools for assembly of Sequencing Data. (PO5)
3. Acquire, analyse, assemble and visualize the genomic sequence data. (PO2, PO12)
4. Select and Apply the NGS technique in diagnosis and treatment of diseases. (PO1, PO5)

Course title	BIOMATERIALS										Credits	3		
Course code	1	9	B	T	6	D	E4	B	I	M	L –T- P	3	0	0

COURSE PRE-REQUISITES: Knowledge of basic cell and molecular biology, Human physiology, Chemistry, Basics of Biomolecules

COURSE DESCRIPTION: this course deals with the concepts and different types of biomaterials, artificial organs available/development, regulatory aspects pertaining to usage of biomaterials, usage of biological/biocompatible scaffolds in medicine and wound healing.

COURSE OBJECTIVES: To enable the students to understand the nature and applications of biomaterials and usage of biocompatible materials for tissue engineering.

UNIT - 1

CHARACTERIATICS OF BIOMATERIALS [6 L]

Introduction to Materials Science: mechanical properties, Strength and ductility, viscoelasticity. Classification of bio-materials (inert, bioactive and biodegradable) organic functional groups needed for biomaterials, Degradation of biomaterials, Protein adsorption to materials.

UNIT - 2

IMPLANT MATERIALS & BIOCOMPATIBILITY [7 L]

Metallic implant materials, stainless steels, co-based alloys, Ti-based alloys, ceramic implant materials, aluminum oxides, hydroxyapatite and glass-ceramics, polymers, dental materials, woundhealing process and body response to implants, Tissue and blood compatibility.

UNIT- 3 ARTIFICIAL ORGANS AND IN VIVO SYNTHESIS OF TISSUES [6 L]

Artificial Heart, Prosthetic Cardiac Valves, Limb prosthesis, Externally Powered limb Prosthesis, Dental Implants. In vivo synthesis of skin, peripheral nerves. Rules for in vivo synthesis. Regulatory aspects related to tissues, blood products and tissue Engineering.

UNIT- 4

HUMAN TISSUE AND ORGANS [10 L]

Introduction to human tissues and tissue development: stem cells; morphology of human tissues and organs: muscle tissue, adipose tissue, connective tissue, nervous tissue and epithelial tissues. Organs: heart, liver, kidney, pancreas, bone &bone marrow and ECM. Tissue homeostasis and importance of cellular signaling in tissue engineering.

UNIT -5

SCAFFOLDING [10 L]

Architectural, biological, and mechanical features of scaffolds, Biological scaffolds (collagen, lamin, glycosamino glycans, elastin, fibroin). Natural polysaccharides (alginate, dextran, Chitosan, cellulose). Scaffold design fabrication, Tissue biomechanics, drugs, growth factors and regulatory molecules. Hydrogels, polymer microspheres, 3D printing and drug delivery.

PRIMARY REFERENCES

1. Introduction to Biomaterials by Joon Park and RS Lakes.
2. Biomaterials by SV Bhat, Springers publication.

SECONDARY REFERENCES

1. Handbook of Materials for Medical Devices by J R Davis.
2. Biomaterials Science and Engineering by Park JV, Plenum Press, 1984.
3. Catalysis in Chemistry by William Jenck.
4. Bioconjugate Techniques by Greg Hermanson.
5. Biomaterials and regenerative medicine in ophthalmology by T V Chirila, Queensland Eye Institute.

e-BOOKS

1. Cells and Biomaterials in Regenerative Medicine (http://www.intechopen.com/books/cellsand-biomaterials-in-regenerative-medicine) **2.** http://genome.tugraz.at/biomaterials.shtml

MOOCs

1. http://nptel.ac.in/syllabus/syllabus.php?subjectId=113104009
2. http://nptel.ac.in/syllabus/syllabus.php?subjectId=102106036
3. https://www.class-central.com/mooc/494/coursera-introduction-to-tissue-engineering
   http://oyc.yale.edu/biomedical-engineering/beng-100/lecture-22

COURSE OUTCOMES (COs)

1. Compare and distinguish various biomaterials (PO1, PO2)
2. Justify the use of suitable biomaterials for various applications (PO1, PO2)
3. Understand the role of implants in artificial organs (PO1, PO2, PO5)
4. Identify the suitable use of implants in tissue replacement (PO2)

Course Title	INTELLECTUAL PROPERTY RIGHTS										Credits	0			
Course Code	1	9	B	T	6	N	C	I	P	R	L-T-P-S	0	0	0	0

COURSE PRE-REQUISITES: Microbiology, Basics of biomolecules, Biochemistry, Genetic engineering, Bio analytical techniques,

COURSE DESCRIPTION: IPR syllabus in the curriculum emphasize on the legal aspects of intellectual properties. It provides an insight into the monopoly rights conferred to an inventor for the development of innovative processes and products. The course also includes legal perspectives of biotechnological inventions preferably products and processes of genetic modification.

COURSE OBJECTIVES: The course imparts in depth knowledge about intellectual property rights, its types, differences and uses. The students will be exposed to patent drafting, analyzing and comparing with case studies. The course provides essential information to students about the exploration of IP into the field of biotechnology sector with relevant case studies.

UNIT 1 Fundamentals of IP [6 L]

Introduction to IPR, types, Basic principles of Patent laws: Basis for IP protection. Criteria for patentability: Novelty, Utility, and Inventive step, Non obviousness, Non patentable invention (relevant case studies). WIPO and Patent Cooperation Treaty (PCT),

UNIT 2 Patents and its ratification [10L]

Patents: Definition and objectives, Criteria of patenting, Patent filing: Provisional vs nonprovisional, filing procedure, examination and report, patent grant and opposition, Assignment of Patent rights- compulsory license, TRIPS agreement and compulsory licensing (case studies), Indian law on compulsory licensing. Infringement of patents- Law enforcing and relevant BT case studies in United Kingdom, United States and India (case studies). Infringement defenses with case studies.

UNIT 3 IPR IN BIOTECHNOLOGY [10 L]

Commercial potential of BT invention, R & D investments, Rationale and applications. Concept of Novelty and Inventive step in BT, Microorganisms and BT inventions, Moral issues in patenting BT invention. Substantiation of Patent laws & international agreements related to pharma, microbial, environmental, and agricultural and informatics sectors via classical case studies. Traditional knowledge (TK) as IP: Introduction to TK, plant variety protection(UPOV 1991), Plant variety protection in India. Justification for geographical indications, Bioprospecting & Biopyracy – ways to tackle, Protectability of traditional knowledge under existing IP framework.

PRIMARY REFERENCES TEXT BOOKS

1. Basic Intellectual property rights, Paper I, Dr. Ramakrishna, National Law School of India University,
2. Ownership and enforcement of IPR by Dr. T. Ramakrishna, NLSIU, Bangalore **3.** IPR in Botechnology, Volume 4, by Dr. T. Ramakrishna, NLSIU, Bangalore

REFERENCE BOOKS

1. Biotechnologies in developing countries by Sasson A, UNESCO Publishers, 1993.
2. Biological safety Principles and practices by Fleming, D.A., Hunt, D.L., (2000), ASM Press.
3. Intellectual Property and Criminal Law, Bangalore by Gopalakrishnan. N S, National Law School of India Univeristy, 1994.

COURSE OUTCOMES

CO1	Understand IP laws that directly affect the creation, transfer, and licensing of IP with specific reference to patenting issues in biotechnology and pharmaceuticals fields
CO2	Understand the International Agreements pertaining to IP protection and relate them to the current issues
CO3	comprehend the importance of IP protection for biotechnology and other emerging fields highlighting the conflict of interest in the developing and developed world
CO4	elaborate of the traditional knowledge, geographical indicators and farmers' rights catering to the development of nation's economy

Semester-VII

Course Type	Code	Course Title	Credits			Total Credits	Contact hours/ week	Marks		
			L	T	P			CIE	SEE	Total
HS-5	19BT7HSBFS	Bioethics & Society	2	0	0	2	2	50	50	100
BS-7	19BT7BSBIE	Biology for Engineers	2	0	0	2	2	50	50	100
PC-18	19BT7DCIML	Industry Motivated Lab	0	0	1	1	1	50	50	100
PC-19	19BT7DCEQD	Bioprocess Equipment Design & CAED	2	1	1	4	5	50	50	100
PE-5	19BT7DE PE-5	Professional Elective 5	3	0	0	3	3	50	50	100
OE-2	19BT7IEEM/ 19BT7IEIMA	Ecology environmental management/ Instrumental Methods of Analysis	3	0	0	3	3	50	50	100
PW-5	19BT7DCPRW	PW (Mini Project)	0	0	3	3	3	50	50	100
SR-4	19BT7DCSEM	Technical Seminar (Review of Research Publication/ Patent)	1	0	0	1	1	50	50	100
TOTAL			**13**	**1**	**5**	**19**	**20**	**400**	**400**	**800**

PE-5	19BT7DE5PBT	Pharmaceutical Biotechnology	3	0	0	3	50	50	100
	19BT7DE5DAN	Data analytics	3	0	0	3	50	50	100
	19BT7DE5MTE	Metabolic Engineering	3	0	0	3	50	50	100
	19BT7DE5TEN	Biomaterials & Tissue Engineering	3	0	0	3	50	50	50

Semester-VIII

Course Type	Code	Course Title	Credits			Total Credits	Contact hours/ week	Marks		
			L	T	P			CIE	SEE	Total
HS-6	19BT8HSBIP	Bioethics & Biosafety	2	0	0	2	2	50	50	100
PW -4	19BT8DCPW	Major project work	0	0	10	10	10	50	50	100
SR-4	19BT8DCSEM	Technical Seminar	1	0	0	1	1	50	50	100
OE-3	19BT8IEFRS	Forensic science	3	0	0	3	3	50	50	100
NC-3	19BT8NCIHL	Industry handled (QA/QC related) Lab.	Non credit mandatory course							
TOTAL			**6**	**0**	**10**	**16**	**16**	**200**	**200**	**400**

VII- SEMESTER

Course Title	BIOTECHNOLOGY FOR SOCIETY										CREDITS	2		
Course Code	1	8	B	T	7	D	C	B	F	S	L-T-P	2	0	0

COURSE PRE-REQUISITES:

Basic knowledge in biochemistry, cell biology and genetic engineering.

COURSE DESCRIPTION:

To enable the students to understand the interactions of biotechnology and society and the debates, controversies, fears, and hopes that have shaped how we think about bodies, organisms, and life in the twenty-first century. It enables the students to gain knowledge on the various topics such as genetically modified foods, cloning, and stem cells; genetic testing and the potential for discrimination; fears of (and, in some cases, hopes for) designer babies; personal genomics; biosecurity; and biotech art.

COURSE OBJECTIVES:

This course enables the students to understand the interactions of the biotechnology, its products with society. It also helps students to understand the debates, controversies and fears pertaining to biotechnological applications for the society.

UNIT - 1

LIMITS OF BIOTECHNOLOGY AND GENETIC ENGINEERING [4L]

Introduction to Biotechnology, Long History of Biotechnology; Inventing Genetic Engineering, Recombinant DNA Debates

UNIT - 2

OWNING LIFE, GENETICALLY MODIFIED FOODS AND THE BOUNDARIES OF BODILY LIFE [5L]

Biotechnology and Business, Patenting Life; Risk, Regulation, and Our Food, Economics of Eating; Owning Part of You, Freezing, Banking, Crossing

UNIT - 3

MAPPING GENES, MAKING SOCIETY, GENETIC TESTING, DISCRIMINATION, AND BIOETHICS [6L]

Eugenics, Human Genome Project; Genetic Testing, Disability, and Discrimination, Bioethics and Medicine

UNIT - 4

VIRGIN BIRTHS, RE-ROUTING LIFE, MINDING YOUR OWN BIOLOGICAL BUSINESS [6L]

From the Pill to IVF, Cloning; Stem Cells, Designer Babies; Drugs and Designer Bodies, Personal Genomics

UNIT - 5

DIVERSITY OF BIOTECHNOLOGY AND BIOLOGICAL FUTURES [5L]

Biotechnology and Race, Bioprospecting and Biocolonialism; Synthetic Biology and Bioterrorism, Biotechnology and Art

Primary references:

1. Biotechnology and society an introduction: Hallam Stevens. 2016, university of Chicago press.

Secondary references:

1. Book title: New Perspectives on Technology, Values, and Ethics, Part II. Chapter 7: Biotechnology, Ethics, and Society: The Case of Genetic Manipulation. Pages 123-144. 2015. Springer international publishing.
2. Biology is Technology: The Promise, Peril, and New Business of Engineering Life by Robert H. Carlson. Harvard University Press. 2010

COURSE OUTCOMES

1. Describe how scientific and technological developments in the field of biotechnology affect society and the environment. (PO1)
2. Apply knowledge of biotechnology to solve the societal issues in both focused and broad interdisciplinary contexts. (PO1,6)
3. Identify and analyse the impact of biotechnological solutions in societal and environmental context. (PO2,7)
4. Development of biotechnological solutions for the societal needs with appropriate consideration for the public health and safety and legal, cultural and environmental issues. (PO3)

Course Code	18BT7ICBIE	Course Name	BIOLOGY FOR ENGINEERS
Credits	01	L-T-P	2-0-0

COURSE PRE-REQUISITES: None

Course Description:

It is well known that this is the century of biology in which signicant advances in the understanding and application of biological systems are expected. The signicant impact on the world is expected in terms of better healthcare, better processes, better products and an overall better quality of life. Thus, any person can be interested in knowing the fundamentals of biology to be able to understand, or participate in the biological revolution. For example, any engineer, irrespective of the parent discipline (mechanical, electrical, civil, chemical, metallurgical, etc.,) has a high probability of using the disciplinary skills toward designing/improving biological systems in the future. This course is designed to convey the essentials of fundamental concepts in biological science for engineers to understand biology for engineering problems.

Course objectives:

To provide the basic organization of organisms and knowledge about Biological Science for Engineers to understand biology for engineering problems

UNIT - 1

INTRODUCTION TO LIFE [3 Hours]

Characteristics of living organisms, structure of prokaryotic and eukaryotic cell; Introduction to biomolecules: definition, general classification and important functions of carbohydrates, lipids, proteins, nucleic acids, vitamins and enzymes; concept of genes and chromosome

UNIT - 2

CONCEPTS OF ENZYMOLOGY [2 Hours]

Basic concepts in enzyme structure and function, cofactors, enzyme kinetics, modes of inhibition

UNIT – 3

IMMUNOLOGICAL SCIENCE [2 Hours]

Immune system and its types; Functional properties of antibodies; Helper T cells and T cell activation, Importance of Microbiology

UNIT – 4

IMPLEMENTATION OF BIO-NANO SCIENCE [3 Hours]

NanoBiomolecules and its various types; Principles and Application of Biosensor; Basics of Biochips, Bioinformatics and its applications

UNIT - 5

ADVANCES IN BIOLOGICAL SCIENCE **[3 Hours]**

Fundamentals of Bio mechanics, Neural Network, Stem Cell, Introduction to Genetics, Genetic Engineering and its Application.

Course Outcome:

1. To understand the cellular make up and structure and functions of biomolecules
2. To understand basic concepts in enzyme function, kinetics and modes of inhibition
3. To comprehend importance of microbiology and immunological science
4. To comprehend the biological science related to the different disciplinary areas

Text Books:

1. Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011
2. Dr. Sohini Singh and Dr. Tanu Allen, "Biology for Engineers", Vayu Education of India, New Delhi, 2014.
3. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, 7th Edition, W. H. Freeman and Company, New York.

Reference Books:

1. Molecular Biology of THE CELL. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, , Garland Science; 5 edition
2. Simon O. Haykin, Neural Networks and Learning Machines (3rd Edition), Prentice Hall; 3 edition (November 28, 2008).

Online resources

1. www.bio12.com/ch3/RaycroftNotes.pdf
2. www.engineering.uiowa.edu/bme050/cvb-solids.pdf
3. www.biologyjunction.com/mendelian_genetics.html

Course Title	INDUSTRY MOTIVATED LAB													
Course Code	1	9	B	T	7	D	C	I	M	L	Credits	0-0-1	L-T-P	1 – 0 – 0
CIE	100 marks /50 Marks										SEE	50marks		

COURSE PRE-REQUISITES: Knowledge of chemistry, Mathematics and Basics of Biology.
COURSE DESCRIPTION: This course will be handled by experts from industries.
COURSE OBJECTIVES:,this course will help students learn the Good manufacturing practices followed by industries and the importance of quality management in general .

INDUSTRY HANDLED LAB

(2hrs/week)

A) Experiments on GXP

Experiments on GMP – which will handled by Pharma /biopharma industries

Experiments on GCP - which will handled by hospitals /CRO

Experiments on GLP –which will be handled by R&D of industries/academia

B) experiments related to Environment Health& safety (this could be another set of expts.)

Course outcomes:

PO	(CO) COURSE OUTCOMES	Descriptor
	CO 1	understand the importance of quality management in industries / environment Health& safety
PO4	CO 2	Design and conduct experiments related to GXP

Course Title	BIOPROCESS EQUIPMENT DESIGN AND CAED										Credits	4			
Course Code	1	6	B	T	7	D	C	E	Q	D	L-T-P-S	2	1	1	0

COURSE PRE-REQUISITES: Unit Operations, Reaction Engineering, Elements of Engineering Drawing and Elements of Mechanical Engineering

COURSE DESCRIPTION: The course deals with study of various components used in bioprocess plant. This emphasizes on detail design of major equipment used in bioprocess industry.

COURSE OBJECTIVES: The objective of the course is to make students understand the working of various components used in process plant. Students will be able to design the major equipment used in bioprocess industry.

UNIT 1

PART A: THEORY + TUTORIAL

INTRODUCTION TO BIOPROCESS DESIGN [4L+2T]

Nature of design, the anatomy of biochemical manufacturing process, organization of biochemical engineering project, codes and standards, factors of safety, degrees of freedom & design variables, optimization, basic considerations in design, piping and instrumentation, material of construction, symbols of equipment used in process flow diagram

UNIT 2

BIOPROCESS COMPONENTS [4L+3T]

Welding Joints, pipe fittings, Flanged pipe joint, Gland & Stuffing box expansion joint Ball valve, Gate valve, Non- return valve, Diaphragm valve, Centrifugal pump, Peristaltic pump, Bioreactors, types, Importance of Single use bioreactors, Filtration units: Normal flow and tangential flow (TFF) filtration systems and design criteria's.

UNIT 3

PROCESS EQUIPMENT DESIGN AND CAED [20L+6T]

Detailed process and mechanical design of the following equipment
I. Shell and tube exchangers
II. Fermenter
III. Distillation column-Packed bed
IV. Extractor

PART B: LABORATORY

CAD of

1. Flanged pipe joint
2. Gland & Stuffing box expansion joint
3. Ball valve
4. Gate valve
5. Non- return valve
6. Diaphragm valve
7. Centrifugal pump
8. Peristaltic pump
9. Shell and tube exchangers
10. Fermenter
11. Distillation column-Packed bed
12. Extractor

COURSE OUTCOMES

1. Comprehend the importance of parameters required to design process equipment
2. Identify the various symbols used in process flow diagrams
3. Draw the sketches of pipe joints, stuffing box, valves, pumps and bioprocess vessels using CAED
4. Design shell & tube heat exchanger, distillation column and Fermenter for given parameters

	Mapping of COs with POs											
PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	1		2			1						
CO2	1		2									
CO3	1		2									
CO4		3	3									

PRIMARY REFERENCES

1. **Process equipment design** by M V Joshi., V.V Mahajani
2. **Chemical Engineering** by Coulson and Richardson, Vol. 6, 1993.
3. **Principles of fermentation Technology** by P.F. Stanbury and A. Whitaker, Pergamon Press, 1984.

SECONDARY REFERENCES

1. **Process Equipment Design** by Brownell LE and Young EH, John Wiley and Sons, Inc. 2009 **Fermentation and Biochemical Engineering Handbook** by Celeste C. Todaro and Henry C. Vogel 3rd edition, 2014
2. **Bioreactors: Analysis and Design**, by Tapobrata Panda. 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011
3. **Perry's Chemical Engineers' Handbook** by Perry, R.H. Green, D.W. McGraw-Hill. Seventh Edition, 1997.
4. **Unfired pressure vessel** I S Code 2825
5. **Shell and tube heat exchanger specifications**, I S Code 4503

E-B OOKS

1. http://buc.edu.in/sde_book/bio_process.pdf

MOOCs

1. http://nptel.ac.in/courses/103103027/
2. https://online-learning.tudelft.nl/courses/industrial biotechnology
3. http://nptel.ac.in/courses/102106022/16

Course Title	ECOLOGY AND ENVIRONMENTAL MANAGEMENT										Credits	3
Course Code	1	9	B	T	7	I	E	E	E	M	L-T-P	3-0-0

Course Pre-requisites: Very basic knowledge about life forms, environment and ecology.

Course Description: The course covers various aspects of an ecosystem and its components, community characteristics and biogeochemical cycles. This course also includes general population attributes, their distribution and interaction of living components with each other and with environment. This course covers importance of the biodiversity, its protection and environmental issues, policies and regulations.

Course Objectives: To enable the students to gain knowledge on the various environmental issues and the application of biotechnological concepts in the management and sustainability of environment and the various policies and regulations involved.

UNIT1

Introduction to Ecology, Community and Ecosystem: [8 hrs]

Interrelationship between the living world and environment. Biosphere and its components, Environmental concepts (theory of tolerance and limiting factors), Community characteristics, organization and succession in different habitats, Bioenergetics and biogeochemical cycles, Concepts of habitat and niche.

UNIT2

Population and Community Ecology: [12 hrs]

Population Attributes: Density, nasality, mortality, age ratio, sex ratio, Dispersion of population, Exponential and logistic growth, Population interactions, Predation types, Simpsons index, R and K selected species, Host parasite interactions, Social parasitism, Symbiosis with examples

UNIT3

Biogeography: [7 hrs]

Phytogeography: Phytogeographic regions in the world, Major plant communities, Vegetation of India, zoogeography

UNIT4

Biotechnology in environmental management: [13 hrs]

Biodiversity and conservation strategies, success stories conservation, Sustainable utilization, Endangered and threatened species, Germ plasm banks, Sustainable utilization of wastes, Biofertilizers, Microbes as saprophytes, Ecofriendly biopesticides, Bioremediation, bio indicators.

UNIT5

Pollution, environmental impact and protection [8 hrs]

Impact of urbanization and industrialization, Environmental impact assessment, Environmental Pollution, Global climatic changes, National and international guide lines, climate summits(Paris summit), Wild life act of India.

COs:

1. Understand key ecological concepts and the ecological interactions which effect environment
2. Analyze and predict the effects of ecological interactions amongst populations.
3. Understand the phytogeographical and zoogeographical distribution of the world.
4. Understand the principles and concepts related to environmental management.
5. Analyze and evaluate the applicability of various biotechnological principles for maintenance of ecological sustainability.
6. Understand the guidelines and regulatory policies involved in environmental management.

Primary references:

1. Environmental studies: Anubha kaushik, CP KAushik, New age international, 3rd edition

Secondary references:

1. Environmental studies selective and scientific books: Mishra A, New delhi, 2005
2. Basics of environmental science: Allaby. M , Routledge, 2002
3. Elements of Ecology: Smith, TM, Simth RC Istedn. Pearson publications, 2006
4. Environmental science: Miller GT, 11th edition Brooks/cole, 2006.

E-Books:

1. Environmental studies: Erach Bharucha, Univeristy Grants Commission

MOOCs:

1. http://nptel.ac.in/courses/122102006/
2. Biodiversity and Global Change: Science & Action (Coursera): https://www.mooc-list.com/course/biodiversity-and-global-change-science-action-coursera
3. Environmental Challenges: Justice in Natural Resource Management (FutureLearn) https://www.mooc-list.com/course/environmental-challenges-justice-natural-resource-management-futurelearn
4. Environmental Studies: A Global Perspective (edX) https://www.mooc-list.com/course/environmental-studies-global-perspective-edx

DEPARTMENT OF BIOTECHNOLOGY

Course Title	INSTRUMENTAL METHODS OF ANALYSIS (OTHER THAN BT STUDENTS)										**Credits**	**3**		
Course Code to check & change	1	9	B	T	7	I	E	I	M	A	**L-T-P**	**3**	**0**	**0**

Pre-requisites:
Knowledge of basic Physics, Mathematics, Chemistry, Basics of Biomolecules

UNIT 1

ADVANCED MICROSCOPIC TECHNIQUES **[9 hrs]**

Electron Microscopy: Scanning electron microscope, Transmission Electron microsope. Scanning probe microscopy: Atomic force microscope,Scanning tunnelling microscope . Applications

UNIT 2

[9 hrs]

SPECTROSCOPIC TECHNIQUES

Introduction, Modern approaches in Bioanalysis and Bioassays. UV-Visible spectroscopy, Fluorescence spectroscopy, NIR spectroscopy, CD spectroscopy, and Mass spectroscopy, NMR, Xray, Atomic absorption and Flame emission spectroscopic techniques, colorimetry
(Only principle, Instrumentation and applications and no derivation required).

UNIT 3

[7hrs]

ELECTROPHORETIC TECHNIQUES

Electrophoresis; Principle, Design of horizontal and vertical gel electrophoresis apparatus, performing electrophoresis techniques, application of electrophoresis in analysing macromolecules.

UNIT 4

[8hrs]

CHROMATOGRAPHIC TECHNIQUES

Chromatographic techniques; General principles, Paper chromatography, TLC, Column chromatography: Ion exchange, Gel filtration, Affinity and Gas and High performance liquid chromatography techniques and FPLC

UNIT 5

CENTRIFUGATION TECHNIQUES

[6hrs]

Basic principles, Different types of centrifuges, Analytical and Preparative Ultracentrifugationmethods.(Only principle, Instrumentation and applications and no derivation required).

TEXT BOOKS

1. Biophysical Chemistry by Cantor R., and Schimmel P.R
2. Physical Biochemistry by David Freifelder (N H Freeman and Company)
3. Biophysical Principles of Structure & Function by Fred M. Snell & Sidney Shulman

REFERENCE BOOKS

1. Biophysics – An Introduction by Cotterill, Wiley Student Edition
2. Foundations of Biophysics by A.L. Stanford.

E-BOOKS

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson
https://books.google.co.in/books?isbn=052165873X
2. Biophysical Techniques by Iain Campbell
https://0b9411cb7057497b22db0cd9f69e827bce11ede8.googledrive.com/host/0B5XjjBG DoIrhNlFVcVhQWjA2a1k/Biophysical-Techniques-Iain-Campbell-ebook-51iBvNTIHhL.pdf

MOOCs

http://nptel.ac.in/courses/102107028/
http://nptel.ac.in/courses/102103044/

COURSE OUTCOMES

1. Ability to understand and remember the principles and applications of various techniques used in the purification and analysis of biomolecules. (PO1)
2. Ability to select and apply appropriate tools and techniques in the purification and analysis of biomolecules. (PO 5)
3. Ability to critically analyze different techniques used for the purification and analysis of biomolecules. (PO 2)
4. Ability to design solution to problems by applying suitable components of bio-analytical techniques. (PO 3, 7)
5. Ability to work individually and as a team in a multidisciplinary environment. (PO 9)

Knowledge of basic Physics, Mathematics, Chemistry , Basics of Biomolecules

UNIT 1

[9 hrs]

ADVANCED MICROSCOPIC TECHNIQUES

Electron Microscopy : Scanning electron microscope, Transmission Electron microsope. Scanning probe microscopy : Atomic force microscope,Scanning tunnelling microscope . Applications.

UNIT 2

[9 hrs]

SPECTROSCOPIC TECHNIQUES

Introduction, Modern approaches in Bioanalysis and Bioassays. UV-Visible spectroscopy, Fluorescence spectroscopy, NIR spectroscopy, CD spectroscopy, and Mass spectroscopy, NMR, Xray, Atomic absorption and Flame emission spectroscopic techniques, colorimetry
(Only principle, Instrumentation and applications and no derivation required).

UNIT 3

[7hrs]

ELECTROPHORETIC TECHNIQUES

Electrophoresis; Principle, Design of horizontal and vertical gel electrophoresis apparatus, performing electrophoresis techniques, application of electrophoresis in analysing macromolecules.

UNIT 4

[8hrs]

CHROMATOGRAPHIC TECHNIQUES

Chromatographic techniques; General principles, Paper chromatography, TLC, Column chromatography: Ion exchange, Gel filtration, Affinity and Gas and High performance liquid chromatography techniques and FPLC

UNIT 5

[6hrs]

CENTRIFUGATION TECHNIQUES

Basic principles, Different types of centrifuges, Analytical and Preparative Ultracentrifugationmethods.(Only principle, Instrumentation and applications and no derivation required).

TEXT BOOKS:

1. Biophysical Chemistry by Cantor R., and Schimmel P.R
2. Physical Biochemistry by David Freifelder (N H Freeman and Company)
3. Biophysical Principles of Structure & Function by Fred M. Snell & Sidney Shulman

REFERENCE BOOKS

1. Biophysics – An Introduction by Cotterill, Wiley Student Edition
2. Foundations of Biophysics by A.L. Stanford.

E-BOOKS

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson https://books.google.co.in/books?isbn=052165873X
2. Biophysical Techniques by Iain Campbell https://0b9411cb7057497b22db0cd9f69e827bce11ede8.googledrive.com/host/0B5XjjBGDoIrhNlFVcVhQWjA2a1k/Biophysical-Techniques-Iain-Campbell-ebook-51iBvNTIHhL.pdf

MOOCs

http://nptel.ac.in/courses/102107028/
http://nptel.ac.in/courses/102103044/

COURSE OUTCOMES

1. Ability to understand and remember the principles and applications of various techniques used in the purification and analysis of biomolecules. (PO1)
2. Ability to select and apply appropriate tools and techniques in the purification and analysis of biomolecules. (PO 5)
3. Ability to critically analyze different techniques used for the purification and analysis of biomolecules. (PO 2)
4. Ability to design solution to problems by applying suitable components of bio-analytical techniques. (PO 3, 7)
5. Ability to work individually and as a team in a multidisciplinary environment. (PO 9)

Course Title	MINI PROJECT										Credits	3		
Course Code	1	9	B	T	7	D	C	P	W		L-T-P	0	0	3

COURSE OUTCOMES

1. Apply the knowledge of BT to provide solution to solve the complex real-life problem. (PO1)
2. Identify the problem, review and analyze literature & engage in independent & lifelong learning (PO2, PO12)
3. Conduct preliminary experiments and interpret the results by applying the research based knowledge of BT. (PO4)
4. Select and use appropriate tools, techniques & resources for BT solutions with understanding of limitations. (PO5)
5. Apply ethical principles during the execution of project. (PO8)
6. Write effective report & communicate scientifically via oral presentation. (PO10)
7. Execute the project and substantiate the methodology and results individually with in stipulated time period. (PO9, PO11)

BMS COLLEGE OF ENGINEERING, BANGALORE

DEPARTMENT OF BIOTECHNOLOGY

COURSE: SEMINAR

COURSE CODE: 19BT7DCSEM

SEMESTER:VI

COURSE OUTCOMES	
1	Survey the literature for a given or selected topic from research paper/patents.
2	Comprehend data and results provided in the literature and interpret them scientifically
3	Communicate effectively by report writing and presentation.
4	Able to work in team/individually for the seminar.

Course Title	PHARMACEUTICAL BIOTECHNOLOGY										Credits	3		
Course Code	1	9	B	T	7	D	E 5	P	B	T	L-T-P	3	0	0

COURSE PRE-REQUISITES: Biochemistry, Molecular Biology, Basics of Biomolecules, Bioinformatics, Genetic Engineering.

COURSE DESCRIPTION: This course emphasizes on overall idea of applications of biotechnology in the field of pharmaceutics. Students will be introduced to the steps involved in the drug discovery and development process and various guidelines to be followed for its formulations and delivery. The student will be exposed in detail to the knowledge of Pharmacokinetics, Pharmacodynamics, side/toxic effects of the drug and bio therapeutic applications.

COURSE OBJECTIVES: This course is designed to impart beneficial applications of Biotechnology in pharmaceutical industry that uses biological systems, living organisms, or derivatives for drug discovery and development process considering economics, safety and regulatory guidelines to be followed for its formulations and delivery. This course also portraits knowledge of pharmacokinetics, Pharmacodynamics, side/toxic effects of the drug and bio therapeutic applications.

UNIT – 1

INTRODUCTION AND REGULATORY GUIDELINES IN PHARMACEUTICAL BIOTECHNOLOGY [7 L]

Introduction to biopharmaceuticals and pharmaceutical biotechnology, Drug development and Economics, Fundamental principles and practical processes involved in preclinical and early proof-of concept clinical development of a chemical or biological entity. ICH guidelines, Indian FDA regulations.

UNIT – 2

DRUG MANUFACTURE AND FORMULATION [7 L]

Routes of drug administration, Types of dosage form. Manufacturing and evaluation of following dosages: Uncoated tablet, coated tablets, Modified-release drug dosage form – controlled and modified release dosage forms. Target oriented drug delivery system – colonic delivery, enteric-coated drug delivery, pulmonary delivery, liposomes, nanoparticles and biodegradable drug delivery systems. Biotechnology based pharmaceuticals and herbal medicines/formulations.

UNIT - 3

DRUG METABOLISM [10 L]

Evolution of Drug Metabolism, Basic toxicological concepts and principles, Phase I Metabolism (microsomal oxidation, hydroxylation, dealkylation), Phase II Metabolism (Drug conjugation pathway), CYP Families. Pharmacodynamics and Pharmacokinetics of protein based drugs, principles of first-order kinetics, first-order pharmacokinetics: Drug elimination following rapid I V injection, Pharmacokinetics analysis of urine data, Clearance rate as an expression of drug-elimination, Pharmacokinetics of drug eliminated by simultaneous metabolism and excretion, Kinetics of drug absorption, the method of Inspection, Bioavailability, Bioequivalence, Factors affecting drug elimination. Evaluation and estimation of bioavailability and bioequivalence parameters of a drug.

UNIT - 4

TOXICOLOGY [9 L]

Toxicology: Basic concepts, mechanism of action of toxins, biotransformation of toxins & their clearance from the body, toxic intermediates, side effect, adverse effect, acute toxicity, chronic toxicity, toxicity testing, mutagenesis and carcinogenicity, Teratogenesis and drug induced fetal damage, allergic reaction to drugs, First-line of treatment, Antidotes. Pharmocology: general principles of drug action, tachyphylaxis and desensitization, bioassay, animal models of disease and drug evaluation.

UNIT - 5

APPLICATIONS OF BIOTHERAPEUTICS [6 L]

Growth factors: IGF, EGF and Neurotrophic factors; Hormones: Production of human insulin by recombinant DNA technology, Formulation of insulin products, Engineered insulins; Therapeutic enzymes: asparginase and thrombolytics (tPA, SK, UK); Cytokines as biopharmaceuticals: classification with examples, production and medical uses of interferons (α,β,γ).

PRIMARY REFERENCES

1. The Theory and Practice of Industrial Pharmacy by Lachman L, CBS publication-6th edition.

2. Basic and Clinical Pharmacology by Bartram G. Katzung, McGraw Hill Publications, 2004 (Chapter 5), 11th edition.

3. Biopharmaceuticals: Biochemistry and Biotechnology by Gary Walsh 2nd edition, wiley publisher.

4. Process validation in Manufacturing of Biopharmaceuticals: Guidelines, Current Practices and Industrial Case Studies by Anurag S. Rathore, Gail SoferProcess CRC press-3rd edition.

SECONDARY REFERENCES

1. Pharmacology by Rang H. P, 8th edition,Elsevier publication.

2. Pharmaceutical biotechnology: an introduction for pharmacists and pharmaceutical scientists by Daan J. A. Crommelin, Taylor & Francis, 2nd edition.

3. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs by Rodney J. Y. Ho, Milo Gibaldi. Contributor Rodney J. Y. Ho, Milo Gibaldi, Wiley Blackwell-2nd edition.

e-BOOKS

1. Bio-pharmaceuticals. Biochemistry and Biotechnology by Dr. Gary Walsh

2. Essential of Pharmaceutical Chemistry Written by Donald Cairns

3. http://www.bpj-bd.com/

MOOCs

1. https://www.mooc-list.com/

2. https://www.mooc-list.com/course/drug-discovery-development-commercialization

COURSE OUTCOMES

1. Outline the drug development process, its economics and regulatory guidelines. (PO6, PO8)

2. Describe the concepts of tablet manufacturing, formulation, dosage forms and modes of drug delivery (PO6)

3. Distinguish different phases of drug and toxicants metabolism as well as apply concepts of pharmacokinetics and pharmacodynamics in drug development process. (PO5, PO6)

4. Relate application of biopharmaceuticals for different therapeutic conditions. (PO1, PO6)

Course Title	DATA ANALYTICS											Credits	3			
Course Code	1	9	B	T	7	D	E	5	D	A	N	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Basics of computer applications, Bioinformatics, Statistics

COURSE DESCRIPTION: This course emphasizes on need of Data Analytics and its applications to analyse the data. It also portraits the fundamentals of Hadoop, Hive and RHIPE software tool for to analyse the data.

COURSE OBJECTIVES: This course is designed to impart good operational knowledge on basics of Hadoop, Hive and RHADOOP for data analytics. Further students will inculcate these tools and techniques to critically analyse the data.

UNIT-1

INTRODUCTION TO DATA ANALYTICS: [08hours]

Overview of Data Analytics, Need of Data Analytics, Classification of Data: Structured, Semi-Structured, Unstructured, Characteristics of Data, Big Data Technologies, Big data challenges, Applications of Data Analytics, Modern Data Analytic Tools.

UNIT-2

ONLINE ANALYTICAL PROCESSING (OLAP): [07hours]

Introduction, Characteristics of OLAP systems, Multidimensional view and Data cube, Data Cube Implementations, Data Cube operations, Implementation of OLAP and overview on OLAP Softwares.

UNIT-3

HADOOP [07hours]

What is Hadoop?, Architecture, HDFS: features, Architecture, operations, MapReduce, hadoop ecosystem, Configuration, Uses, Limitations.

UNIT-4

HIVE QL **[07 hours]**

Introduction, Data Types and File Formats, Databases in Hive –HiveQL: Data Definition, Data Manipulation, Queries, Views, Indexes, Schema Design

UNIT-5

DATA ANALYSIS USING R AND HADOOP **[10 hours]**

Features of R language, R and Hadoop Integrated Programming Environment (RHIPE): Introduction, Architecture, and function reference, RHADOOP: Introduction, Architecture, function reference, SQL on HADOOP.

PRIMARY REFERENCES

1. Hadoop in practice, ALEX HOLMES. Manning Publications, 2012

2. Programming Hive, Edward Capriolo, Dean Wampler, and Jason Rutherglen. O'Reilly

   Media, First Edition.

3. Prajapati, V. Big data analytics with R and Hadoop. Packt Publishing Ltd, 2013

4. Pang-Ning Tan, Michael Steinbach, Vipin Kumar: Introduction to Data Mining, Pearson Education, 2005.

SECONDARY REFERENCES

1. An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics. W. N. Venables, D.M. Smith and the R Development Core Team. Version 3.3.3.

2. Tom White " Hadoop: The Definitive Guide" Third Edition, O"reilly Media, 2011

E-BOOKS:

1. https://www.tutorialspoint.com/hadoop/hadoop_tutorial.pdf
2. http://it-ebooks.info/book/608/

MOOCs:

1. https://www.coursera.org/browse/data-science/data-analysis
2. https://www.mooc-list.com/tags/data-analysis

COURSE OUTCOMES

1. Comprehend the basics of Hadoop, Hive and RHADOOP (PO1) [L3]
2. Apply HADOOP and RHADOOP to analyse the data (PO5) [L2]
3. Design big data applications schema and use HIVE QL to analyse the data. (PO5 [L1]

Course Title	METABOLIC ENGINEERING										Credits	3		
Course Code to check & change	1	9	B	T	7	D	E5	M	T	E	L-T-P-S	3	0	0

COURSE PRE-REQUISITES: Basics of Biomolecules, Biochemistry and Bioenergetics, Cell and Molecular Biology, Genetic Engineering, and Process Engineering Thermodynamics and

Biostatistics.

COURSE DESCRIPTION: This course includes methods for metabolic characterization (genome, transcriptome, proteome, metabolome and fluxome), comprehensive models for cellular reactions, regulation of metabolic pathways, metabolic flux analysis and applications of metabolic flux analysis. This course also includes methods for the experimental determination of metabolic fluxes by isotope labelling, metabolic control analysis, metabolic design (gene amplification, gene-disruption, randomized and targeted strain development) and metabolic Engineering in practice.

COURSE OBJECTIVES: This course provides insight into the fundamentals of metabolic engineering in strain improvement programs to increase the yield of a target product or reduce or eliminate the production of undesired impurities. This course imparts knowledge on development of optimization procedures for strain improvement, optimizing metabolic flux by up-regulation of a target pathway and/or knock-out of competing pathways and heterologous expression of foreign gene / gene cluster to introduce metabolites for biosynthesis of target product.

UNIT - 1

METABOLIC CHARACTERIZATION AND MODELS FOR CELLULAR REACTIONS [7 L]

Overview to the field with illustrating examples. Central Metabolism: Fueling metabolism,

Supply of biomass precursors, Anabolism, Anaplerosis. Coordination of metabolic reactions: Feedback inhibition, Energy charge, Multigene networks. Methods for metabolic characterization: Genome, Transcriptome, Proteome, Metabolome and Fluxome. Comprehensive models for cellular reactions: Stoichiometry of cellular reactions, Reaction rates, Dynamic mass balance.

UNIT - 2

REGULATION OF METABOLIC PATHWAYS AND METABOLIC FLUX ANALYSIS [9 L]

Regulation of metabolic pathways: Regulation of Enzymatic Activity and Enzyme concentration, Regulation at whole cell level, Regulation of Metabolic networks. Metabolic flux analysis: Overdetermined and undetermined systems, Sensitivity analysis.

UNIT - 3

METHODS FOR METABOLIC FLUX ANALYSIS AND ITS APPLICATIONS [7 L]

Methods for Metabolic Flux Analysis; Metabolite Balancing, Tracer Experiments, MS and NMR in labelling measurement. Applications of metabolic flux analysis.

UNIT – 4

METABOLIC CONTROL ANALYSIS AND METABOLIC DESIGN [9 L]

Metabolic control analysis (MCA): Determination of Flux control coefficients, MCA of Linear and Branched pathways. Metabolic design: Gene amplification, Gene disruption, Randomized and targeted strain development.

UNIT - 5

METABOLIC ENGINEERING IN PRACTICE (Case studies) [7 L]

Engineering the isobutanol biosynthetic pathway in *Escherichia coli* by comparison of three aldehyde reductase/alcohol dehydrogenase genes; Compartmentalization of metabolic pathways in yeast mitochondria improves the production of branched-chain alcohols; Metabolic engineering of *Escherichia coli* to increase NADH availability by overexpressing an NAD+-dependent formate dehydrogenase; Engineering *Escherichia coli* for production of functionalized terpenoids using plant P450s; Industrial production of amino acids by coryneform bacteria; Engineering of *Escherichia coli* for fuel production (Microdiesel).

PRIMARY REFERENCES

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998.
2. David Fell, Understanding the Control of Metabolism, Portland Press, London, 1997.

SECONDARY REFERENCES

1. S. Y. Lee & E.T. Papoutsakis, Metabolic Engineering, Marcel Dekker, New York, 1999.
2. R.Heinrich and S. Schuster, The Regulation of Cellular Systems, Chapman & Hall, 1996.
3. E.O. Voit, Computational Analysis of Biochemical Systems. Cambridge University Press, 2000.

e-BOOKS

1. https://books.google.co.in/books/about/Metabolic_Engineering.html?id=9mGzkso4NV QC
2. http://onlinelibrary.wiley.com/doi/10.1016/S0307-4412(97)87557-7/abstract

MOOCs

1. http://www.nptel.ac.in/syllabus/102103014/

COURSE OUTCOMES

1. Elucidate central metabolic reactions and models used for cellular reactions (PO1).
2. Comprehend regulation of metabolic pathways at different levels and analyze metabolic flux for real time applications (PO1, PO2).
3. Describe the metabolic control analysis and plan a suitable metabolic design for maximizing product yield (PO3).
4. Relate applications of metabolic engineering for current research/industrial practices (PO1, PO12).

COURSE TITLE	BIOMATERIALS &TISSUE ENGINEERING										CREDITS	3			
COURSE CODE	1	9	B	T	7	D	E	T	E	N	L T P S	3	0	0	0

Pre-requisites: Knowledge of basic cell and molecular biology, Human physiology, Chemistry, Basics of Biomolecules

UNIT 1

[6 hrs]

Introduction to tissue engineering, Cells as therapeutic Agents and examples, Cell numbers and growth rates. Tissue organization, Tissue Components, Tissue types, Functional subunits. Tissue Dynamics, Tissue repair. Angiogenesis

UNIT2

[6 hrs]

Biomaterials: Properties of biomaterials, Surface, bulk, mechanical and biological properties. Biomaterial Scaffolds, Types of biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials. [9 hrs**]**

UNIT 3

[7 hrs]

Artificial Heart, Prosthetic Cardiac Valves, Limb prosthesis. In vivo synthesis of skin, nerves Artificial blood vessels, Artificial pancreas, Artificial liver. Regulatory aspects related to tissues, blood products and tissue Engineering.

UNIT 4

[10hrs]

BASIC BIOLOGY OF STEM CELLS: Stem Cells: Introduction, Potency and plasticity of stem cells, Stem Cell markers, FACS analysis, Stem cell systems- Liver, neuronal stem cells, embryonic, adult, haematopoetic, fetal, cord blood, placenta, bone marrow, cancer stem cells induced pluripotent stem cells. Applications of stem cells.

UNIT5

[10 hrs]

SCAFFOLDING

architectural, biological, and mechanical features of scaffolds, Biological scaffolds (collagen, lamin, glycosamino glycans, elastin, fibroin). Natural polysaccharides (alginate, dextran, Chitosan, cellulose). Scaffold design fabrication, drugs, growth factors and regulatory molecules. Hydrogels, polymer microspheres, 3D printing.

COURSE OUTCOMES

1. Compare and distinguish various biomaterials

2. Justify the use of suitable biomaterials for various applications

3. Understand the role of artificial organs

4. Classify various stem cells and their applications.

	PO1	PO2	Po3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3											1		
CO2	1	3											1		
CO3	1	3			1								1		
CO4		2													

Primary references:

1. "Tissue Engineering", Bernhard O. Palsson, Sangeeta N. Bhatia, Pearson Prentice Hall Bioengineering
2. Nanotechnology and Tissue engineering - The Scaffold", Cato T. Laurencin, Lakshmi S. Nair, CRC Press
3. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P. .Fundamentals of Tissue Engineering and Regenerative Medicine.2009

Secondary References

1. R. Lanza, J. Gearhart etal (Eds), Essential of Stem Cell Biology, Elsevier Academic press,2006

E-Books:

Cells and Biomaterials in Regenerative Medicine (http://www.intechopen.com/books/cells-and-biomaterials-in-regenerative-medicine)
http://genome.tugraz.at/biomaterials.shtml

MOOCS

https://www.class-central.com/mooc/494/coursera-introduction-to-tissue-engineering
http://oyc.yale.edu/biomedical-engineering/beng-100/lecture-22
https://nptel.ac.in/courses/102/106/102106036/
https://nptel.ac.in/courses/102/106/102106081/

VIII - SEMESTER

Course Title	BIOETHICS & BIOSAFETY										Credits	2		
Course Code	1	9	B	T	8	H	S	B	I	P	L-T-P	2	0	0

COURSE PRE-REQUISITES: Knowledge of Constitution of India and Professional Ethics, Microbiology, Genetic engineering, Pharmaceutical BT, Animal BT, Plant BT

COURSE DESCRIPTION: The course deals with impact of biotechnology on society, ELSI of biotechnology solutions, biosafety levels and regulations.

COURSE OBJECTIVES: On completion of the course, students will have fundamental knowledge on concepts of ELSI and safety issues governing a technology.

UNIT 1

BIOTECHNOLOGY AND SOCIETY [3L]

Introduction to science, technology and society; biotechnology and social responsibility - public acceptance issues in biotechnology - issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, globalization and development divide. Case studies/experiences from developing (Bt cotton and Bt brinjal) and developed countries; Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.

UNIT 2

BIOETHICS AND CONFLICTS IN BIOTECHNOLOGY [3L]

Introduction; Ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics, Issue of technology transfers across the globe.

UNIT 3

BIOETHICS IN HEALTH CARE & RESEARCH [7L]

Medical ethics - Basic principles of medical ethics; Bioethics in health-care - Patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation; Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Synthetic or artificial cell, HGP and its issues, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

UNIT 4

BIOSAFETY CONCEPTS AND ISSUES [8L]

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels - GRAS organisms, biosafety levels of specific microorganisms, recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs

cisgenic plants or products derived from RNAi, genome editing tools; Bio-safety issues in clinical trials; Biological weapons - types and possible role of RDT in production of novel bioweapons; social, economic and ethical implications of bioterrorism.

UNIT 5

BIOSAFETY REGULATIONS AND GUIDELINES [5L]

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

COURSE OUTCOMES

1. Understand the basic structure of ethical principles of modern BT and biosafety practices.
2. Apply the concepts and guidelines of bioethics and biosafety practices in execution of research and projects. (PO1, PO6)
3. Analyze and interpret the case studies associated with inventiveness, ethics and biosafety in real world scenario. (PO2)
4. Reason, anticipate and evaluate appropriately the ethical, legal and social issues associated with biotechnological processes and products. (PO8)
5. Investigate the case study, conduct surveys, collect data associated with bioethics and biosafety practices, individually work and compile in a report the interpretations from the methods and results. (PO9, PO10)

PRIMARY REFERENCES

1. **Bioethics & Biosafety** by Sateesh MK (2008), IK Publishers.
2. **Biotechnology and Safety Assessment** by Thomas by J.A., Fuch, R.L. (2002), Academic Press.

SECONDARY REFERENCES

1. **Biotechnologies in developing countries** by Sasson A, UNESCO Publishers, 1993.
2. **Biological safety Principles and practices** by Fleming, D.A., Hunt, D.L., (2000), ASM Press.

E-BOOKS

1. https://vufind.carli.illinois.edu/vf-tiu/Record/tiu_576971

MOOCs

1. https://www.mooc-list.com/course/bioethics-law-medicine-and-ethics-reproductive-technologies-and-genetics-edx

Course Title	MAJOR PROJECT WORK									Credits	10		
Course Code	1	9	B	T	8	D	C	P	W	L-T-P	0	0	10

COURSE OUTCOMES

1. Apply the knowledge of BT to provide solution to solve the complex real-life problem. (PO1)

2. Identify the problem, review literature & engage in independent & lifelong learning. (PO2, PO12)

3. Select and use appropriate tools, techniques & resources for BT solutions with understanding of limitations. (PO5)

4. Apply reasons to assess societal, health, safety issues and the impact of sustainable solutions to the problem chosen. (PO6, PO7)

5. Design experiments with appropriate consideration for safety and environment. (PO3)

6. Apply ethical principles during the execution of project. (PO8)

7. Conduct the experiments, analyze, and interpret data to derive valid conclusions using research based knowledge. (PO4)

8. Write effective report & communicate scientifically via oral presentation. (PO10)

9. Execute the project in team with in stipulated time period. (PO9, PO11)

DEPARTMENT OF BIOTECHNOLOGY

Course Title	TECHNICAL SEMINAR										Credits	1		
Course Code	1	9	B	T	8	D	C	S	E	M	L-T-P	1	0	0

Course Outcomes:

1. Survey literature pertaining to given problem
2. Formulate the problem, plan and conduct experiment in a given time period
3. Apply various BT Techniques to derive a valid conclusion
4. Write effective report and present effectively by oral communication
5. Ability to work individually or team.

	Mapping of COs with POs											
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	2											2
CO2		1	2			1					1	
CO3					2							
CO4										2		
CO5									1			

Course Title	FORENSIC SCIENCE										Credits	3		
Course Code	2	1	B	T	8	I	E	F	R	S	L-T-P	3	0	0

Pre-requisites:

Knowledge of Human Physiology, Engineering Chemistry and Physics, Biology for Engineers.

UNIT 1

[06 hrs]

INTRODUCTION

Introduction to Forensics, Definition and scopes of forensics, History and chronology of the events in forensics, (Contribution of various scientists and forensic experts in forensic sciences), and important milestones in the forensics, importance and significance of court in forensics (procedure and protocol:- Inquest and different types, medical examiners systems, powers of courts, different documentary evidences and witness, Doctors guide to court), application of the forensics in various fields.

UNIT 2

[10 hrs]

CRIME LAB & THE CRIME SCENE

Crime lab:

Organization of crime lab at various levels in India (Center and State), Basic services provided by full service crime laboratories (physical, biological unit, firearms unit, Document Examination unit, photograph unit, - functions and duties), optional services provided by full service crime laboratories (lie detector, toxicology, voice print analysis unit).

The Crime Scene:

Processing the crime scene (Crime scene, Preservation and record, methodic search for evidence, Collection and package of the evidences, maintain chain of custody, crime scene safety).

Physical evidences: common types & sources of physical evidences, Handling, packing and labeling of evidence, Individual and class characteristics, significance of physical evidences.

UNIT 3

[10 hrs]

FORENSIC ANALYSIS

Glass (nature of information obtained, properties, glass fractures, collection and preservation of glass evidence); Soil (forensic characteristics, collection and preservation); Hairs (Morphology, Identification and comparison, collection), Fibers (Types, Identification), semen, paint (collection, nature & examination), Blood (stain patterns, preservation, characterization).Selecting an analytical technique to identify a organic substance (Gas Chromatography, High Performance Liquid Chromatography, Thin Layer Chromatography, Electrophoresis)

UNIT 4

[08 hrs]

FORENSIC BIOLOGY

Forensic Pathology (Rigor mortis, Lovor mortis, Algor mortis); Forensic Anthropology, Forensic Entomology, Forensic Psychiatry, Forensic odontology, Forensic Engineering, DNA Analysis, Finger prints (Classification and patterns, ridge characteristics, Methods of detecting fingerprints).

UNIT 5

[05 hrs]

COMPUTER CRIME & ETHICS IN FORENSICS

Computer crime: Introduction and definition, classification (Physical, Data & software related), computer crime prevention measures, overview of cyber forensics.

Ethics in forensic science: Introduction, The importance of professional ethics to science practitioners, Various models of codes of ethics (broad model and Detailed model), How ethical requirement, impact the daily work of a forensic scientist, ethical dilemmas and their resolution.

TEXT BOOKS

1. **Criminalistics: An Introduction to Forensic Science** by Richard Saperstein, Prentice Hall, 2001.
2. **Forensic Science in Crime Investigation** by B.S.Nabar, Asia Law House, 3rd edition, 2007

REFERENCE BOOKS

1. **Principles of Forensic Medicine** by Apurba Nandy, New central book agency (p) Ltd.
2. **M.K.R.Krisnas's Handbook of Forensic Medicine including Toxicology** by V. P. Patnaik, Pras Medical Books, 11th edition, 1999.

Course Outcomes:

By the end of the course, students should be able to:

1. Comprehend the basic concepts of forensic sciences viz., legal procedure and protocols required to solve cases and ethics involved in forensic sciences.

2. Apply the concepts of forensic sciences to solve criminal cases.PO1
3. Analyze the crime scenes and physical evidences based on the nature of evidences.PO2
4. Identify a suitable case study, prepare a report and communicate effectively.PO2,10

Course Title	INDUSTRY HANDLED (QA/QC RELATED) LAB.													
Course Code	1	9	B	T	8	N	C	I	H	L	Credits	0	L-T-P	1 – 0 – 0
CIE	100 marks /50 Marks										SEE	50marks		

COURSE PRE-REQUISITES: Knowledge of chemistry, Mathematics and Basics of Biology.
COURSE DESCRIPTION: This course will be handled by experts from industries.
COURSE OBJECTIVES: This course will help students learn the protocols followed by industries for quality management and quality assurance wr.t biotechnology sector.

Quality management and quality assurance

Introduction- Good Manufacturing Practices, Good Laboratory Practices, SOP for GMP and GLP Good Clinical Practice, TQM, TPM, Six Sigma and internal auditor training as per ISO recommendations.

Course outcomes:

(CO) COURSE OUTCOMES	Descriptor
CO 1	Understand the importance of QA & QM in industries.
CO 2	Have the ability to carry out the SOP for GMP and GLP
CO 3	Have the ability to carry out internal audits w.r.t. QA & QM