B.Tech
in
Biotechnology
&
Biochemical
Engineering

OFFERED

BY

DEPARTMENT OF BIO ENGINEERING,
NIT-AGARTALA

VISION

To Produce the Bright Young Professionals by Quality Education & Research in the Emerging Field of Biotechnology & Biochemical Engineering to Fulfill the Societal Commitments at per Global Standard

MISSION

- To impart quality education for fundamental knowledge in engineering science and technology with social responsibilities.
- To develop the engineering background of students towards employability, entrepreneurship, Research and higher studies.
- To develop continuous improvement in teaching learning process through interactive sessions, industry-academia interaction.
- To make good human beings possessing Professional Ethics.

PEOs (Program Educational Objectives)

- To empower students for attaining competence in identifying, formulating and solving Biological problems by applying their knowledge in the field of science and engineering skills to meet the challenges, demands and expectations on global context.
- To establish an understanding of professionalism, ethics, quality performance in order to become professional leaders and contributors to the society.
- To initiate program for life-long learning that provides continuous development of the technical abilities and professional skills to become successful professionals and entrepreneurs.
- To Prepare Students to Pursue Higher Studies in the Area of Biotechnology & Biochemical Engineering in India or Abroad

PSOs (Program Specific Outcomes)

PSO -1	To acquire competency in applications of basic engineering principle in biological system to apply in industry and research
PSO -2	To recognize the importance of bioethics and environmental impact to apply in any technical solution

POs (Program Outcomes)

PO-1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO-2	**Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	**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.
PO-4	**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.
PO-5	**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.
PO-6	**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.
PO-7	**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.
PO-8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	**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.
PO-11	**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.
PO-12	**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.

SEMESTER III

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Theory								
1		Biochemistry	**3**	**0**	**0**	**3**	**3**	**100**
2		Microbiology	**3**	**0**	**0**	**3**	**3**	**100**
3		Biochemical Reaction Engineering	**2**	**1**	**0**	**3**	**3**	**100**
4		Heat & Mass Transfer in Biological Systems	**2**	**1**	**0**	**3**	**3**	**100**
5		Engineering Mathematics-III *(offered by Math Department)*	**3**	**0**	**0**	**3**	**3**	**100**
6		Engineering Economics and Accountancy *(offered by HSS Department)*	**3**	**0**	**0**	**3**	**3**	**100**
Laboratory								
1		Biochemistry Laboratory	**0**	**0**	**3**	**3**	**2**	**100**
2		Microbiology Laboratory	**0**	**0**	**3**	**3**	**1.5**	**100**
3		Biochemical Reaction Engineering Laboratory	**0**	**0**	**3**	**3**	**1.5**	**100**
							23	**900**

SEMESTER IV

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Theory								
1		Molecular Biology & Genetics	**3**	**0**	**0**	**3**	**3**	**100**
2		Recombinant DNA Technology	**3**	**0**	**0**	**3**	**3**	**100**
3		Transport phenomena in Biological Systems	**2**	**1**	**0**	**3**	**3**	**100**
4		Bioprocess Engineering	**2**	**1**	**0**	**3**	**3**	**100**
5		Principles of Management and Managerial Economics *(offered by HSS Department)*	**3**	**0**	**0**	**3**	**3**	**100**
Laboratory								
1		Recombinant DNA Technology Laboratory	**0**	**0**	**3**	**3**	**1.5**	**150**
2		Mass Transfer Laboratory	**0**	**0**	**3**	**3**	**1.5**	**150**
3		Fluid Mechanics Laboratory	**0**	**0**	**3**	**3**	**1.5**	**150**
4		Bioprocess Engineering laboratory	**0**	**0**	**3**	**3**	**1.5**	**150**
							21	**1100**

SEMESTER V

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Theory								
1		Immunology and Immunotechnology	3	0	0	3	3	100
2		Bioinformatics and Computational Biology	3	0	0	3	3	100
3		Downstream Processing	2	1	0	3	3	100
4		Biochemical Process Calculation	2	1	0	3	3	100
5		Departmental Elective-I	3	0	0	3	3	100
6		Departmental Elective-II	3	0	0	3	3	100
Laboratory								
1		Bioinformatics and Computational Biology Laboratory	0	0	3	3	1.5	150
2		Heat Transfer Laboratory	0	0	3	3	1.5	150
							21	900

SEMESTER VI

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Theory								
1		Process Biotechnology	2	1	0	3	3	100
2		Bioprocess instrumentation & Control	2	1	0	3	3	100
3		Animal Biotechnology	3	0	0	3	3	100
4		Intellectual Property Right (IPR)	1	0	0	1	0 (Non-credit Course)	100
5		Departmental Elective-III	3	0	0	3	3	100
6		Departmental Elective-IV	3	0	0	3	3	100
7		Departmental Elective-V	3	0	0	3	3	100
Laboratory								
1		Downstream Processing Laboratory	0	0	3	3	1.5	150
2		Immunotechnology Laboratory	0	0	3	3	1.5	150
							21	1000

SEMESTER VII

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Theory								
1		Environmental Biotechnology	3	0	0	3	3	100
2		Plant Biotechnology	3	0	0	3	3	100
3		Biophysical and Bioanalytical Techniques	2	1	0	3	3	100
4		Departmental Elective-VI	3	0	0	3	3	100
5		Open Elective-I	3	0	0	3	3	100
Laboratory								
1		Project-I	0	0	6	6	2	100
2		Seminar	0	0	3	3	1	100
							18	700

SEMESTER VIII*

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Theory								
1.		Departmental Elective-VII	3	0	0	3	3	100
2.		Departmental Elective-VIII	3	0	0	3	3	100
3.		Open Elective-II	3	0	0	3	3	100
Laboratory								
1.		Project-II	0	0	6	6	3	100
2.		Comprehensive Viva	0	0	3	3	1	100
							13	500

***SEMESTER VIII (If project being carried out at industry)**

Sl.No.	Code	Course Title	L	T	P	H	Credit	Marks
Laboratory								
1.		Industrial Project	0	0	40	40	10	300
2.		Project Seminar	0	0	3	3	2	100
3.		Comprehensive Viva	0	0	3	3	1	100
							13	500

Distribution of credits

Sl. No	Semester	Credit	Marks
01	SEMESTER I	43	
02	SEMESTER II		
03	SEMESTER III	23	900
04	SEMESTER IV	21	1100
05	SEMESTER V	21	900
06	SEMESTER VI	21	1000
07	SEMESTER VII	18	700
08	SEMESTER VIII	13	500
	Total	160	5100

ELECTIVES

DEPARTMENTAL ELECTIVES

1. Bioprocess plant design
2. Thermodynamics in biological systems
3. Metabolic Engineering & Systems Biology
4. Genomics and Proteomics
5. Protein Structure and Engineering
6. Tissue Engineering
7. Food Process Engineering
8. Pharmaceutical Biotechnology
9. Biological Waste Treatment
10. Biostatistics
11. Synthetic Biology
12. Valorization of Biomass
13. Molecular Basis of Diseases
14. IPR and Biosafety
15. Modelling and Simulation for Biological Systems
16. Drug Design and Development
17. Students can choose any course from Digital Platforms. Those courses must be available during that particular session. Besides, the approval of competent authority of NITA is applicable for those online courses.

OPEN ELECTIVES

1. Biosensors
2. Computational Fluid Dynamics in Biology
3. Bio-Nanotechnology
4. Biomaterials
5. Students can choose any course from Digital Platforms. Those courses must be available during that particular session. Besides, the approval of competent authority of NITA is applicable for those online courses.
6. Any course may be taken as open elective subject offered by other departments of NITA, if available in respective session.

SEMESTER III

1. Name of the Subject: BIOCHEMISTRY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Biochemistry**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Structure and function of biomolecules: Amino acids, Carbohydrates, Lipids, Proteins and Nucleic acids; Protein structure, folding and function: Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin.

Module 2: Biological membranes, structure, action potential and transport processes; Enzymes- classification, kinetics and mechanism of action; Basic concepts and designs of metabolism (carbohydrates, lipids, amino acids and nucleic acids) photosynthesis, respiration and electron transport chain; Bioenergetics.

Module 3: Signal transduction; Hormones and neurotransmitters.

Module 4: Biochemical separation techniques: ion exchange, size exclusion and affinity chromatography, Characterization of biomolecules by electrophoresis, UV-visible and fluorescence and phosphorescence.

4.Text/Reference:

a. David L. Nelson and Michael M. Cox: Lehninger Principles of Biochemistry, Palgrave Macmillan, Freeman, Low Price Edition, 4th Edition, 2007.
b. Mary K. Campbell and Shawn O. Farrell: Biochemistry, Thomson Brooks/Cole, Indian Edition, 5th Edition, 2007.
c. Voet & Voet, Principles of Biochemistry. John Wiley & Sons Limited.

5.Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the basic structures and functions of the macromolecules.
CO-2	Understand basic tools for investigating macromolecules.
CO-3	Understanding of the major cell signaling pathways.
CO-4	Overall, gaining an understanding of the biochemical processes of metabolic transformation at the molecular level.
CO-5	Comprehensive understanding of the working mechanisms of the biological systems and about the recent advancements in the field.

6.CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High) and for No Correlation :--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	1	1	1	1	1	-	1	-	-	2	3	3
CO-2	2	2	2	2	3	1	2	-	2	-	-	2	3	3
CO-3	-	2	2	2	3	1	1		1	2	-	1	2	2
CO-4	1	2	1	1	-	1	2	-	1	2	-	2	3	2
CO-5	-	1	2	2	2	1	1	-	1	2	-	2	3	2
Total	4	9	8	8	9	5	7	-	6	6	-	9	14	12
Average	1	2	2	2	2	1	1	-	1	2	-	2	3	2

SEMESTER III

1. Name of the Subject: MICROBIOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Microbiology**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Microbes and life today, Methods of microbiology, Cultivating microorganisms; Theory and practice of sterilization; Evaluation of effectiveness of antimicrobial agents. Principles of microbial nutrition; Enrichment culture techniques for isolation of microorganisms. Bacteria, Archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy.

Module 2: Definition of growth; Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth. Environmental factors that influences microbes, Microbial growth, Microbial Genetics, Bacteriophages, Bacterial Plasmids.

Module 3: Energetics: redox reactions and electron carriers; An overview of metabolism; Entner-Doudoroff pathway; Glyoxalate pathway; Fermentation; Aerobic and anaerobic respiration; Chemolithotrophy; Photosynthesis; Calvin cycle.

Module 4: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs. Viruses- structure and classification; Aerobic and anaerobic respiration; Nitrogen fixation; Microbial diseases and host-pathogen interaction. Microbial interactions; Carbon, sulphur and nitrogen cycles; Soil microorganisms associated with vascular plants.

4. Text/Reference:

a. Michael J. Pelczar, Jr., E.C.S. Chan, Noel R. Krieg: Microbiology, Tata McGraw Hill, 5th Edition, 2006.
b. John L. Ingraham, Catherine A. Ingraham: Introduction to Microbiology, A case History Approach, Thomson Brooks/Cole, 3rd Edition, 2004.
c. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton: Prescott, Harley, and Klein's Microbiology, McGraw Hill Higher Education, International Edition, 7th Edition, 2007.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Have an appreciation of the practice of microbiology, sterilization processes, physical and chemical methods used to control microbial growth.
CO-2	Understanding of basic instruments/tools for the culturing of microbes
CO-3	Clear conception on structure of bacterial cells, major metabolic pathways within a bacterial cell.
CO-4	Understanding of nutritional and physical requirements for bacterial growth.
CO-5	Understanding of microbial pathogenesis and antimicrobial agents.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	-	1	1	-	3	1	1	1	-	2	3	3
CO-2	2	2	2	1	3	1	3	1	2	-	-	2	3	3
CO-3	-	2	2	2	3	1	1	-	1	2	-	1	2	2
CO-4	1	2	1	1	-	1	2	-	1	2	-	2	3	2
CO-5	-	1	2	2	2	1	1	-	1	2	-	2	3	2
Total	4	9	7	7	9	4	10	2	6	7	0	9	14	12
Average	1	2	1	1	2	1	2	0	1	1	0	2	3	2

SEMESTER III

1. Name of the Subject: BIOCHEMICAL REACTION ENGINEERING

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Biochemical Reaction Engineering**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Reactor design: Rate law, Order, molecularity and rate law, elementary and non elementary reaction, reversible reaction. Classification of reactors, design equations for batch, flow and semi batch reactors and their performance. Collection and interpretation of rate data using batch and flow reactors. Space time, space velocity; Conversion and reactor sizing: concept of conversion, Levenspiel's plot, reactors in series and parallel.

Module 2: Residence Time Distribution (RTD): fundamentals of non-ideal reactors; measurement and characterization of RTD: C curve, E curve, F curve, Mean Residence Time, RTD for ideal reactor (batch, CSTR, PFR, PBR, FBR); non ideal reactor modeling using RTD: Zero Parameter Model: Segregation model & maximum mixedness; Tanks in Series Model; Dispersion Model.

Module 3: Biochemical reaction systems: Enzyme kinetics: Michaelis-Menten kinetics, inhibition by foreign substances, kinetics of competitive and noncompetitive inhibitions, Models for more complex enzyme kinetics, effect of pH and temperature, inhibition kinetics.

Module 4: Reaction catalyzed by solids: Introduction to heterogeneous reactions, rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics. Methods of immobilization, immobilized enzyme kinetics. Performance equations for PFR, PBR and FBR. Effect of pressure drop on conversion for PFR and PBR, FBR.

4. Text/Reference:

1. Fogler, HS, "Elements of Chemical Reaction Engineering", PHI, 4th ed., 2010
2. Levenspiel O, Chemical Reaction Engineering, Wiley India Pvt Ltd, 3rd ed., 2007
3. Smith JM, Chemical Engineering Kinetics, McGraw-Hill, 2nd edition, 1970
4. Roulings, "Chemical Reactor Analysis".

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the reaction mechanism, order and types of biochemical reaction
CO-2	Development of design equations for batch, flow and semi batch reactors and their performance study.
CO-3	Understand the conversion, Levenspiel's plot, conversion when reactors in series and parallel.
CO-4	Understand Residence Time Distribution (RTD) for ideal reactor (batch, CSTR, PFR, PBR, FBR) & non ideal reactor modeling using RTD
CO-5	Understand the kinetic behavior of heterogeneous and homogeneous catalysis process

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	3	2	1	-	-	-	-	-	-	-	3	-
CO-2	2	3	3	2	1	-	-	-	-	-	-	-	3	-
CO-3	2	3	3	2	1	-	-	-	-	-	-	-	3	-
CO-4	2	3	3	2	1	-	-	-	-	-	-	-	3	-
CO-5	2	3	3	2	1	-	-	-	-	-	-	-	3	-
Total	10	15	15	10	5	-	-	-	-	-	-	-	15	-
Average	2	3	3	2	1	-	-	-	-	-	-	-	3	-

SEMESTER-III

1. **Name of the Subject: HEAT AND MASS TRANSFER IN BIOLOGICAL SYSTEM**
2. **Credit Structure:**

Course Name		Credit			Marks (Weightage)		
Name	Heat and Mass Transfer in Biological system	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. **Course Content:**

Module-I: Heat transfer: Classification of heat flow processes. Heat flow in fluids by conduction, convection and radiation. Governing Equations and Boundary conditions of heat transfer. Metabolism and regulation of body temperature; physiological radiative, convective, conductive heat transfer; heat transfer resistance in the body. Counter-current and parallel flow. Enthalpy balance in heat exchange equipment. Individual heat transfer coefficients, overall coefficient, Heating and cooling of fluids.

Module II: Heat Transfer with Change of Phase: Freezing of pure water, solution, cells and tissues, Freezing time calculation. Heat transfer equipment: heat exchanger, condenser, boiler, heat transfer in agitated vessel, heat transfer in pack bed. Unsteady state heat transfer. Design equation & Application: Design equation for heat transfer system, application of Design equation, and Hydrodynamic consideration with cooling coil. Application of heat transfer to bioreactor system: with reference to both heat generation and removal. Bio-heat transfer equation for mammalian tissue

Module III: Mass transfer: Diffusion: Fick's first and second law for steady and unsteady state diffusion. Single phase mass transfer, transport between phases; diffusion across a membrane, cellular transport mechanisms, macroscopic species balances, compartmental analyses, microscopic species conservation, gas exchange in the lungs and tissues. Analogy between heat and mass transfer. Properties of gases, liquids, biological solutions, ice and solids.

Module –IV: Absorption: The mechanism of absorption, Diameter and height calculations for packed columns, equilibrium solubility of gases in liquids; counter-current multi-stage absorption; continuous contact equipment; multi-component systems. Extraction: Liquid- liquid extraction and liquid solid extraction (Leaching). Co-current and countercurrent extractor; Adsorption: Mechanism, Batch and continuous adsorption. Application of adsorption in biological system.

4. **Text/Reference:**

1. Treybal RE, "Mass Transfer Operations", MGH, International student Edition, 3rd edition, 1981.
2. Binay K. Dutta, "Principles of Mass Transfer and Separation Processes", PHI, 4th Ed., 2010.
3. Geankoplis, "Transport process and Unit Operations", PHI, 4th Ed., 2007.
4. McCabe, Smith, and Harriot, "Unit Operations in Chemical Engfueering", MGH, 5th Ed., 1993.
5. Wankat PC, "Equilibrium-Staged Separations", Prentice Hall, 1989
6. Coulson & Richardson, Chemical Engineering, Vol-I & II:, Butterworth Heinemann; D.Q. Kern. Process Heat Transfer. McGraw-Hill Inc., US.

5. **Course Outcomes:**

No. of course outcome	Name of the course outcome
CO-1	Ability to apply principles of mass transfer and heat transfer in biological system
CO-2	Ability to perform design calculation for absorption, adsorption and extraction column
CO-3	Ability to understand various laws in heat and mass transfer
CO-4	Thorough understanding of diffusional mass transfer

6. **CO-PO Matrices & CO-PSO Mapping of courses:**

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	3	3	2	3	3	-	1	-	-	-	-	-	3	-
CO-2	3	3	3	3	3	1	1	-	-	-	-	-	3	-
CO-3	3	3	2	3	3	-	1	-	-	-	-	-	3	-
CO-4	3	3	2	-	-	-	-	-	-	-	-	-	3	-
Total	12	12	9	9	9	1	3	-	-	-	-	-	12	-
Average	3	3	2.25	3	3	1	1	-	-	-	-	-	-	-

SEMESTER-III

1. Name of the Subject: BIOCHEMISTRY LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Biochemistry Laboratory**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	80	20

3. Course Content:

a. Estimation of amino acid by UV method.
b. Estimation of protein by UV method
c. Estimation of protein by Bradford method
d. Glucose estimation by DNSA method
e. Estimation of starch
f. Estimation of enzyme (Amylase) Activity
g. Carbohydrate estimation by GOD-POD Method
h. Estimation of lipid
i. Amino Acid- Titration Curve
j. Detection of the isoelectric point of casein
k. Determination of protease activity
l. Protein purification (Ammonium Salt PPt.)
m. Protein purification (Column Chromatography)
n. Estimation of nucleic acids by UV method

4. Text/Reference:

a. Plummer Mu, David T. Plummer, Introduction to Practical Biochemistry, Tata McGraw-Hill Education, 1988
b. J. Sambrook, E.F. Fritsch, T. Maniatis. Molecular Cloning: A Laboratory Manual (Volume I, II & III), Cold Spring Harbor Laboratory press.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Able to explain principles of the performed experiments.
CO-2	Demonstrate proper operation of the equipment and instruments used in this course.
CO-3	To acquire the knowledge of standard of practice for safe handling of reagents.
CO-4	Able to solve their unknown problems and document the results in laboratory reports.
CO-5	Complete exams that require problem solving and creative thinking.

6. CO-PO Matrices & CO-PSO mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	3	1	1	1	-	1	-	-	2	3	3
CO-2	3	3	-	3	3	1	2	-	2	-	1	2	3	3
CO-3	2	1	2	2	3	1	1	-	1	2	-	1	2	2
CO-4	2	2	2	-	2	1	2	-	1	2	-	2	3	2
CO-5	1	1	3	2	2	1	-	2	1	2	1	2	3	2
Total	11	10	8	10	11	5	6	2	6	6	2	9	14	12
Average	2	2	2	2	2	1	1	-	1	1	-	2	3	2

SEMESTER-III

1. Name of the Subject: MICROBIOLOGY LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Microbiology Laboratory**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	80	20

3. Course Content:

a. Preparation of liquid and solid culture medium and sterilization of medium
b. Gram staining and microscopic examination for morphometric analysis
c. Study different phases of bacterial growth and determination of Specific growth rate and Doubling time
d. Bacterial count : spectroscopic vs plate count method
e. Biochemical test for bacterial identification(Catalase activity test, Imvic test)
f. Staining of bacteria (Grams, Acid Fast and Capsular)
g. Staining of bacterial spores by Malachite green or acid fast staining
h. Citrate Utilization Test (Distinguish between coliform bacteria)
i. Use of selective and differential media
j. Antibiotic susceptibility testing using Disk diffusion test
k. Inoculation of fungus in PDA & YEPD medium (Petri dish and broth medium)
l. Growth and microscopic examination of fungal culture
m. Isolation and preservation of pure culture from natural source

4. Text/Reference:

a. Emanuel Goldman and Lorrence H Green . Practical Handbook of Microbiology, Second Edition, CRC Press, ISBN-13: 978-8123900346
b. G. D. Gupta and R. S. Gaud. Practical Microbiology, Nirali Prakashan.
c. Sherman, Microbiology : A laboratory manual. Benjamin Science publishing.
d. John Harley, Microbiology Lab Manual, McGraw-Hill Science / Engineering / Math.
e. John G. Holt, David Hendricks Bergey, R.S. Breed, Bergey's Manual of Determinative Bacteriology, Wolters Kluwer.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Able to successfully perform streak plate isolation technique; bacterial staining techniques; and proper culture handling.
CO-2	Demonstrate proper operation of the equipment and instruments used in this course.
CO-3	To acquire the knowledge of standard of practice for safe handling of reagents and microbes.
CO-4	Able to solve their unknown problems and document the results in laboratory reports.
CO-5	Complete exams that require problem solving and creative thinking.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation:--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	1	3	1	1	1	-	1	-	-	1	3	3
CO-2	2	2	-	2	3	0	1	-	2	1	1	2	2	2
CO-3	1	1	-	2	2	1	1	1	1	-	-	-	3	2
CO-4	2	2	1	1	2	-	2	-	-	2	-	1	2	3
CO-5	1	1	3	-	1	1	-	2	1	2	1	2	3	2
Total	8	9	5	8	9	3	5	3	5	5	2	6	13	12
Average	2	2	1	2	2	1	1	1	1	1	0	1	3	2

SEMESTER-III

1. Name of the Subject: BIOCHEMICAL REACTION ENGINEERING LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biochemical Reaction Engineering Lab	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	80	20

3. Course Content: Kinetics of Batch reactor, Continuous stirred tank reactor, plug flow reactor, residence time distribution studies, sterilization kinetics, enzyme and immobilized enzyme kinetics.

4. Text/Reference:

1. Fogler, HS, "Elements of Chemical Reaction Engineering", PHI, 4th ed., 2010
2. Levenspiel O, Chemical Reaction Engineering, Wiley India Pvt Ltd, 3rd ed., 2007

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Estimate the rate constant and order of batch reaction
CO-2	Estimate the rate constant and order of flow reaction
CO-3	Estimate residence time distributions in batch and flow bioreactors.
CO-4	Estimate specific death rate of batch sterilization
CO-5	Estimate rate constant for enzymatic reaction

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-2	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-3	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-4	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-5	2	3	2	1	2	-	-	-	-	-	-	-	3	-
Total	10	15	10	5	10	-	-	-	-	-	-	-	15	-
Average	2	3	2	1	2	-	-	-	-	-	-	-	3	-

SEMESTER-IV

1. **Name of the Subject: MOLECULAR BIOLOGY & GENETICS**
2. **Credit Structure:**

Course Name		Credit			Marks (Weightage)		
Name	**Molecular Biology & Genetics**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. **Course Content:**

Module 1: Molecular structure of genes and chromosomes;
Module 2: Nucleic acid replication, transcription, translation and their regulatory mechanisms in prokaryotes and eukaryotes; Mutations and mutagenesis;
Module 3: Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance.
Module 4: Microbial genetics (plasmids, transformation, transduction, conjugation);
Module 5: Horizontal gene transfer and Transposable elements; RNA interference; DNA damage and repair; Chromosomal variation; Molecular basis of genetic diseases.

4. **Text/Reference:**

a. B. Alberts, A. Johnson, J.Lewis and M.Raff, *Molecular Biology of the Cell,* Garland Science; 5th edition.
b. H. Lodish, A Berk, C.A. Kaiser and M.Krieger, *Molecular Cell Biology*, W. H. Freeman**,** 6th edition, 2007.

5. **Course Outcomes:**

No. of course outcome	Name of the course outcome
CO-1	Understanding of gene and genetic material within a bacterial cell; the types of mutations that may occur in bacterial DNA.
CO-2	Understanding of evolution of bacteria, the use of nucleic acid in the molecular taxonomy of bacterial species.
CO-3	Clear conception on replication, transcription and translation process used by prokaryotes and eukaryotes.
CO-4	Understanding of how proteins are secreted and exported to different cellular compartments and appreciate the role of membrane.
CO-5	Understand controlling mechanism of gene expressions in prokaryotes.

6. **CO-PO Matrices & CO-PSO Mapping of courses:**

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	-	1	-	1	-	-	1	-	2	2	2
CO-2	3	3	-	1	2	-	1	1	2	1	1	2	2	2
CO-3	3	3	-	2	2	1	1	1	1	1	-	3	2	2
CO-4	2	2	1	1	2	-	2	-	-	1	-	1	2	3
CO-5	1	1	3	-	1	1	-	2	1	1	1	2	3	2
Total	12	12	5	4	8	2	5	4	4	5	2	10	11	11
Average	2	2	1	1	2	0	1	1	1	1	0	2	2	2

SEMESTER-IV

1. **Name of the Subject: RECOMBINANT DNA TECHNOLOGY**

2**. Credit Structure:**

Course Name		Credit			Marks (Weightage)		
Name	**Recombinant DNA Technology**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Restriction and modification enzymes; Vectors; plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome; mammalian and plant expression vectors.

Module 2: DNA labeling; DNA sequencing; Polymerase chain reactions; DNA fingerprinting; Southern and northern blotting; In-situ hybridization; RAPD, RFLP.

Module 3: cDNA and genomic DNA library; Gene isolation, cloning and expression; Transposons and gene targeting, Site-directed mutagenesis; Gene transfer technologies; Gene therapy

4. Text/Reference:

1. Principles of Gene Manipulation; S. B. Primrose, R. Twyman, R.W. Old; Wiley-Blackwell; 6th Edition.
2. Gene Cloning and DNA Analysis: An Introduction, T A Brown; Wiley-Blackwell; 6th Edition

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand basic and advanced techniques in Genetic Engineering.
CO-2	Select appropriate host and vector system for cloning and expression.
CO-3	Understand the cloning strategies and expression of recombinant molecules
CO-4	Understand the gene regulation mechanism in bacteria and eukaryotic hosts.
CO-5	Apply genetic engineering principles for biotechnological and biomedical applications.

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	-	2	1	-	-	1	-	-	-	-	3	3
CO-2	-	3	3	3	2	-	-	2	-	-	-	-	3	-
CO-3	-	3	3	3	2	-	-	-	-	-	-	-	3	3
CO-4	3	3	-	1	-	-	-	-	-	-	-	-	3	-
CO-5	1	2	3	3	-	2	-	-	-	-	1	2	3	3
Total	7	13	6	12	5	2	-	3	-	-	1	2	15	9
Average	2.33	2.6	3	2.4	1.6	2	-	1.5	-	-	1	2	3	3

SEMESTER IV

1. Name of the Subject: TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Transport Phenomena in Biological Systems	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Truncation and round-off errors, Interpolation; Least-squares regression; root finding techniques; Solution of algebraic and transcendental equations; Numerical differentiation; Numerical Integration; Numerical Solution of ODEs; Numerical Solution of PDEs.

Module 2: Physical properties of fluids; types of fluids; governing laws of fluid flow: integral and differential relations; Bernoulli's equation, flow of incompressible fluids in pipes; laminar and turbulent flow; flow of fluids through solids; compressible flow, measurement of fluid flow parameters; fluid machineries.

Module 3: Constitutive relations for biological fluids; Hemodynamics; blood flow in microcirculation; transport in digestive system; fluid dynamics in vestibular system; transport in plants: xylem and phloem; Diffusion and osmosis; Fick's law; diffusion with convection or electrical potentials; transport in porous media; membrane transport: active and passive transport; advection-diffusion equation; diffusion processes in human systems; gas exchange in the pulmonary system; transvascular transport; solvent and solute transport across the kidney glomerulus; mixing in digestive system.

4. Text/Reference:

1. FM White; Fluid Mechanics; McGraw-Hill; 7th ed.
2. SC Chapra & RP Canale; Numerical Methods for Engineers; McGraw-Hills; 5th ed.
3. RB Bird, WE Stewart and EN Lightfoot; Transport Phenomena; Wiley & Sons.
4. Jagan Majumder; Biofluid Mechanics; World Scientific.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understanding basics of numerical methods and their applications in biological field
CO-2	Understanding various laws governing fluid flow, fluid types, measurement machineries, and viscosity, pressure, velocity relations
CO-3	Understanding the flow types, friction factors, dimension less numbers.
CO-4	Understanding the transport mechanisms in biological systems, diffusion, convection
CO-5	Understanding the combinatorial transport mechanisms that govern the functions of living systems

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO -5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO -1	PSO -2
CO-1	3	1	-	2	-	-	-	-	-	-	-	-	3	-
CO-2	3	1	-	2	-	-	-	-	-	-	-	-	3	-
CO-3	3	1	-	2	-	-	-	-	-	-	-	-	3	-
CO-4	3	1	-	2	-	-	-	-	-	-	-	-	3	-
CO-5	3	1	-	2	-	-	-	-	-	-	-	-	3	-
Total	15	5	-	10	-	-	-	-	-	-	-	-	15	-
Average	3	1	-	2	-	-	-	-	-	-	-	-	3	-

SEMESTER IV

1. Name of the Subject: BIOPROCESS ENGINEERING

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bioprocess Engineering	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module1: Media and air Sterilization: Introduction. Medium sterilization, design of batch sterilization processes. Calculation of the Del factor during heating and cooling; Calculation of the holding time at constant temperature. Sterilization of media by membrane filters. Design of continuous sterilization processes: Sterilization of fermenter, Sterilization of feeds, Sterilization of liquid wastes. Air sterilization: Various types of sterilization equipments.

Model –III: Cell growth, substrate utilization and product formation kinetics: Quantification of cell growth, growth patterns and kinetics in batch culture, environmental factors affecting growth kinetics, heat generation by microbial growth, unstructured / structured, non segregated / segregated models, models for transient behaviour, kinetics of substrate utilization, Yield and maintenance coefficients, kinetics of product formation. Continuous Flow Reactors: CFSTR, Fed Batch Reactor, PBR, PFR, FBR and MBR.

Module- II: Agitation and aeration: Introduction, Basic Mass-Transfer Concepts, types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_La), measurement of k_La, power requirement for agitation in gaseous and non gaseous systems, Gas Hold-Up: Gas Sparging with or without Mechanical Agitation. Scale-up: various criteria for scale-up.

Model –IV: Operating considerations for bioreactors: Choosing the cultivation methods, Batch, fed-batch and continuous mode of operation. Chemostat with cell recycle, Stability analysis.

4. Text/Reference:

1. M.L. Shuler and F.Kargi, Bioprocess Engineering: Basic Concepts(2nd Edition), Prentice Hall PTR; 2 edition, 2001.
2. Doran, Bioprocess Engineering Principles. Academic Press.
3. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill Higher Education, 2nd edition, 1986
4. James M. Lee, Biochemical Engineering. Prentice Hall.
5. Douglas S. Clark, Harvey W. Blanch. Biochemical Engineering. CRC Press.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the roles and responsibilities of a bioprocess engineer
CO-2	Understand sterilization techniques and estimate the sterilization time
CO-3	Understand the rheology of fermentation fluids and determine the power requirement in bioreactors
CO-4	Develop the design equations for bioreactors and calculate the oxygen demand for cell growth.
CO-5	Understand the scale up concepts for bioprocesses

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	1	3	1	1	-	-	-	-	-	-	-	3	2
CO-2	2	3	3	1	1	-	-	-	-	-	-	-	3	3
CO-3	2	3	3	2	1	-	-	-	-	-	-	-	3	-
CO-4	2	3	3	2	2	-	-	-	-	-	-	-	3	-
CO-5	2	3	3	1	1	-	-	-	-	-	-	-	3	-
Total	11	13	15	7	6	-	-	-	-	-	-	-	15	5
Average	2.2	2.6	3	1.4	1.2	-	-	-	-	-	-	-	3	2.5

SEMESTER-IV

1. Name of the Subject: RECOMBINANT DNA TECHNOLOGY LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Recombinant DNA Technology Laboratory**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	2	-	80	20

3. Course Content:

1. Bacterial plasmid DNA Extraction and analysis by agarose gel electrophoresis
2. Isolation of genomic DNA from microbes and Plant
3. Isolation of RNA from various sources
4. Amplification of Genomic DNA by Random primers using PCR
5. Restriction digestion of genomic DNA.
6. Ligation of digested DNA into the expression vector
7. Preparation of Competent cell
8. Transformation of recombinant DNA into host
9. Isolation of recombinants and confirmation of insert DNA in vector (selection of recombinant colonies)

4. Text/Reference:

1. John R. W. Masters, Animal Cell Culture: A Practical Approach. Oxford University Press
2. J. Sambrook, E.F. Fritsch, T. Maniatis. Molecular Cloning: A Laboratory Manual (Volume I, II & III), Cold Spring Harbor Laboratory press

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Exposure to standard operating procedure of safe laboratory practices and operation of laboratory equipments
CO-2	Isolation of nucleic acids from biological samples
CO-3	Understanding of quality and quantity of nucleic acids by different bio-analytical techniques
CO-4	Understanding of gene expression strategies

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	3	-	-	-	2	2	3	1	-	1	2	3	3
CO-2	1	1	1	1	2	-	-	-	-	-	-	-	1	1
CO-3	-	3	1	3	2	-	-	-	-	-	-	-	1	1
CO-4	3	3	3	3	3	2	2	-	-	-	-	-	3	3
Total	4	10	5	7	7	4	4	3	1	-	1	2	8	8
Average	2	2.5	1.66	2.33	2.33	2	2	3	1	-	1	2	2	2

SEMESTER-IV

1. Name of the Subject: MASS TRANSFER LAB

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**MASS TRANSFER LAB**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	80	20

3. Course Content:

1. To determine the drying rate and equilibrium moisture content of given sample at various temperature.
2. To determine mass transfer coefficient in solid-liquid agitation system
3. To determine the diffusivity coefficient of acetone in air by natural diffusion
4. To find out volumetric mass transfer coefficient for gas absorption
5. To determine extraction efficiency of lipid using various organic solvent
6. To study mass transfer in adsorption system in batch and continuous mode
7. Estimation of partition coefficients of two immiscible liquid
8. Determination of mass transfer coefficient for steady state surface evaporation of water at different temperature
9. Determination of ternary curve
10. Verification of Rayleigh equation in a binary batch distillation process

4. Text/Reference:

1. McCabe and Smith, Unit Operation of Chemical Engg
2. Gavhane Unit operation Chemical Engineering,.
3. Treyball, Mass Transfer Operation
4. Treybal, R. E.: "Mass transfer Operations", 3rd ed., McGraw-Hill, New York, 1980
5. Seader, J.D., E. J. Henley, and D. K. Roper: "Separation Process Principles – Chemical and Biochemical Operations", 3rd ed., John Wiley, New Jersey, 2011.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Ability to understand safe handling of chemical reagents
CO-2	Ability to operate the equipment and instruments used in this course.
CO-3	To know how to analyze and report experimental data in a methodical manner
CO-4	Ability to conduct experiments involving mass transfer in chemical and biochemical systems.

6. CO-PO Matrices & CO-PSO mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	3	2	1	1	1	1	1	2	-	-	-	3	-
CO-2	2	3	2	2	3	1	1	1	3	2	1	-	3	-
CO-3	2	3	2	3	1	1	-	-	-	3	1	-	3	-
CO-4	3	3	2	3	3	1	1	1	2	2	1	-	3	-
Total	8	12	8	9	8	4	3	3	7	7	3	-	12	-
Average	2	3	2	2.25	2	1	1	1	2.33	2.33	1	-	3	-

SEMESTER IV

1. Name of the Subject: FLUID MECHANICS LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)	
Name	**FLUID MECHANICS LABORATORY**	**L**	**T**	**P**	**End**	**Internal**
Code		0	0	3	80	20

3. Course Content:

Flow through open channel, straight pipe, bends; frictional losses; Bernoullis theorem; flow measuring instruments; Reynold number quantification; instruments for pumping; fluid dynamics

4. Text/Reference:

1. FM White; Fluid Mechanics; McGraw-Hill; 7th ed.
2. SC Chapra& RP Canale; Numerical Methods for Engineers; McGraw-Hills; 5thed.
3. RB Bird, WE Stewart and EN Lightfoot; Transport Phenomena; Wiley & Sons.
4. JaganMajumder; Biofluid Mechanics; World Scientific.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Ability to Utilize basic measurement techniques of fluid mechanics
CO-2	Ability to understand the differences among measurement techniques, their relevance and applications.
CO-3	Estimate the friction and measure the frictional losses in fluid flow.
CO-4	experiment with flow measurement devices like venturimeter and orifice meter
CO-5	Understand different principles related to fluid flow, flow velocity, bernouli`s theorem.

6. CO-PO Matrices & CO-PSO mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	1	3	1	1	-	-	2	1	-	1	2	-
CO-2	3	-	1	3	3	1	-	-	2	2	-	-	2	-
CO-3	2	-	3	2	3	1	-	-	2	-	-	-	2	-
CO-4	2	-	3	2	3	1	-	-	2	-	-	-	2	-
CO-5	2	2	1	1	1	1	-	-	1	-	-	-	2	-
Total	12	4	9	11	11	5	-	-	9	3	-	1	10	-
Average	2.4	2	1.8	2.2	2.2	1	-	-	1.8	1.5	-	1	2	-

SEMESTER IV

1. Name of the Subject: BIOPROCESS ENGINEERING LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bioprocess Engineering Laboratory	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	30	50	20

3. Course Content: The Microbial cell growth kinetics, Preparation and characterization of immobilized enzyme, Determination of kinetic constants in free and immobilized enzyme systems, Analysis of mass transfer effects of kinetics of the immobilized enzyme reactions, Bio-conversion studies with immobilized enzyme packed bed reactors, Effect of pH and temperature on enzyme activity, Kinetics of enzyme inhibition activity, Production of secondary metabolites in synthetic and complex industrial media, Estimation of monod parameters in batch, fed-batch and continuous cultures and Solid state fermentation.

4. Text/Reference:

1. Brian McNeil and Linda Harvey. Practical Fermentation Technology. Wiley
2. S. Kulandaivelu (Author), S. Janarthanan. Practical Manual on Fermentation Technology. I K International Publishing House Pvt. Ltd; First Edition edition
3. Paul Cutler. Protein Purification Protocols. Humana Press; 2nd edition

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Estimate specific growth rate and development of growth kinetics model.
CO-2	Estimate the monod parameters in batch, fed-batch and continuous cultures
CO-3	Investigate the effect of pH and temperature on enzyme activity
CO-4	Determination of kinetic constants in free and immobilized enzyme systems
CO-5	Determination of conversion efficiency of immobilized enzyme packed bed reactors

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-2	2	3	3	1	2	-	-	-	-	-	-	-	3	-
CO-3	2	3	3	1	2	-	-	-	-	-	-	-	3	-
CO-4	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-5	2	3	1	1	2	-	-	-	-	-	-	-	3	-
Total	10	15	11	5	10	-	-	-	-	-	-	-	15	-
Average	2	3	2.2	1	2	-	-	-	-	-	-	-	3	-

SEMESTER-V

1. Name of the Subject: IMMUNOLOGY AND IMMUNOTECHNOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Immunology and Immunotechnology	L	T	P	Mid	End	Internal
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Primary and secondary lymphoid organ; B and T cells and macrophages; Innate, humoral and cell mediated immunity; Antigen; Antibody structure and function. Molecular basis of antibody diversity; Synthesis of antibody and secretion;

Module 2: Antigen-antibody reaction; Complement; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody, Hybridoma technology

Module 3: Regulation of immune response; Immune tolerance; Hypersensitivity; Autoimmunity; Graft versus host reaction.

4. Text/Reference:

Kuby Immunology, by Judy Owen, Jenni Punt, Sharon Stranford, Patricia Jones;

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Able to understand the various mechanisms that regulate immune responses and maintain the tolerance
CO-2	Able to understand the adverse effect of immune system including Allergy, hypersensitivity and autoimmunity
CO-3	Able to apply basic techniques for identifying antigen and antibody interactions.
CO-4	Able to explain the stages of transplantation of various transplant procedures
CO-5	Able to elucidate the reasons for immunization and aware of different vaccination

6. CO-PO Matrices & CO-PSO mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-2	3	3	3	3	-	-	1	-	-	-	-	2	1	3
CO-3	3	3	3	3	-	-	-	-	-	-	-	2	1	3
CO-4	3	3	3	3	2	-	3	3	-	-	-	2	2	3
CO-5	3	3	3	3	1	-	3	2	-	-	-	2	2	3
Total	15	15	15	14	3	-	7	5	-	-	-	10	7	14
Average	3	3	3	2.8	1.5	-	2.33	2.5	-	-	-	2	1.4	2.8

SEMESTER-V

1. Name of the Subject: BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bioinformatics and Computational Biology	L	T	P	Mid	End	Internal
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Introduction to Biological databases and Alignment: types of databases, Sequence Analysis, Pairwise alignment, Dot matrix Scoring function, Substitution matrix, Dynamic programming, BLAST and FASTA algorithms, Multiple sequence alignment:

Module 2: Phylogenetic analysis: Molecular clock theory, Distance and character-based methods, Phylogenetic tree evaluation: Bootstrap analysis.

Module 3: Genomics: Genome sequencing, annotation, Basic principles of microarray, Gene prediction algorithms, Machine learning techniques: Artificial Neural Networks, Hidden Markov Models

Module 4: Proteomics: Structure classification of proteins (SCOP, CATH); Secondary structure prediction, Tertiary structure prediction (homology modeling and fold recognition), Protein protein interaction, protein-protein, protein-nucleic acid, protein-ligand interaction, Molecular docking.

4. Text/Reference:

a) Arthur Lesk; Introduction to Bioinformatics, Oxford University Press, Second edition, 2002

b) David W. Mount; Bioinformatics: Sequence and Genome Analysis; CSHL Press; First edition, 2001

c) Andreas D. Baxevanis, Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins. Wiley-Interscience, 3rd edition 2004

d) Richard Durbin; Sean R. Eddy; Anders Krogh; Graeme Mitchison; Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Cambridge University Press, 3rd edition, reprint 2008.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	To understand the Scope of Bioinformatics and the importance of biological database using online resources
CO-2	To acquire the contextual knowledge of sequence alignment and testing the accuracy of predicted alignment
CO-3	To analyze and develop the phylogenetic model for better interpretation of biological data for public health.
CO-4	To predict the genome structure using probabilistic model
CO-5	To analyze the structure and function of Protein using contemporary bio informatics tools and IT resources.

6. CO-PO Matrices &CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	2	2	3	-	1	-	-	1	-	2	3	-
CO-2	2	2	1	3	3	-	-	-	-	1	-	1	3	-
CO-3	2	3	3	3	3	2	1	-	-	1	-	2	3	1
CO-4	3	3	2	3	2	-	-	-	-	-	-	1	3	-
CO-5	2	2	2	3	3	2	1	-	-	1	-	2	3	-
Total	11	11	10	14	14	4	3	-	-	4	-	8	15	1
Average	2.2	2.2	2.0	2.8	2.8	0.8	0.6	-	-	0.8	-	1.6	3	0.2

SEMESTER-V

1. Name of the Subject: DOWNSTREAM PROCESSING

3. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Downstream Processing	L	T	P	Mid	End	Internal
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Overview of upstream and downstream processing of bioprocess, Role and importance of Downstream process in biotechnological processes.

Module 2: Cell disruption methods, Precipitation of protein by different methods, Sedimentation, Flocculation, Filtration, Centrifugation, Adsorption, Extraction.

Module 3: MEMBRANE BASED SEPARATION PROCESS: fundamentals of membrane based separation, Microfiltration, Ultrafiltration, Reverse osmosis, concentration polarization, Dialysis, Electrodialysis, Diafiltration. CHROMATOGRAPHY: principles, instruments and practice, adsorption, reverse phase, ion exchange, size exclusion, HPLC.

Module 4: ELECTROKINETIC METHOD OF SEPARATION: Electrophoresis, Capillary electrophoresis, Isoelectric focusing. PRODUCT FINISHING OPERATION: Crystallization, Drying, Lyophilization, Case studies of the downstream processing of Baker's yeast, ethanol, citric acid.

4. Text/Reference:

1. Roger G Harrison et al "Bioseparation Science and Engineering" Oxford University Press, 2003
2. Belter PA and Cussler E, " Bioseparations", Wiley 1985
3. Christie J Geankoplis, "Transport processes and unit operations" Allyn& Bacon, 1978

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand separation techniques used in downstream process
CO-2	Design and optimize downstream processes
CO-3	Understand the requirements for successful operation of downstream processes
CO-4	Understand the principles of major unit operations used in downstream processing of biopharmaceuticals.
CO-5	Understand the downstream processing of various products

6. CO-PO Matrices &CO-PSO Mapping of courses:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	1	1	-	-	-	-	-	-	-	3	-
CO-2	2	3	3	1	2	-	-	-	-	-	-	-	3	-
CO-3	2	3	3	1	2	-	-	-	-	-	-	-	3	-
CO-4	2	3	3	3	2	-	-	-	-	-	-	-	3	-
CO-5	2	3	2	2	2	-	-	-	-	-	-	-	3	-
Total	10	15	13	8	9	-	-	-	-	-	-	-	15	-
Average	2	3	2.6	1.6	1.8	-	-	-	-	-	-	-	3	-

1. Name of the Subject: BIOCHEMICAL PROCESS CALCULATION

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biochemical Process Calculation	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Introduction to process calculations: Units & Dimensions, Dimensional Consistency, Conversion of units, Mole & mole fractions, Stoichiometric relationship and yield concepts, Presentation and analysis of experimental data: Mean median mode and standard deviation.

Module2: Perception of Ideal gas, Vapour pressure and Humidity: Behaviour of ideal gases and its application to gaseous mixtures, Law of Dalton and Amagat, Densities of gaseous mixture; Vapour pressures: Liquefaction, Vaporization, Boiling point, Vapour pressures of solids and liquids, Raoult's law, Humidity & Saturation.

Module 3: Fundamentals of Material balance: problems with and without reactions, concepts of Excess reactant, Limiting Reactant, Degree of completion; Elemental balance, Growth and product stoichiometry.

Module 4: Concept of Energy balance: Enthalpy calculation procedure, Heat capacity of gases, liquid and solids, Latent heat, Heat of reaction, formation and combustion, solution and dilution. Energy balance of reactive and non-reactive processes enthalpy concentration charts, Calculation of heat of reaction for biomass production, energy balance equation for microbial growth and cell culture.

4. Text/Reference:

a) *Pauline M Doran., "Bioprocess Engineering Principles"; Publisher: Elesvier Science & Technology.*
b) *Hougen OA et. Al., Chemical Process Principles (Vol.1); Publisher: CBS Publishers And Distributors Pvt Ltd.*
c) *Felder RM and Rousseau RW, "Elementary Principles of Chemical processes", John wiley.*

***5.* Course Outcomes:**

No. of course outcome	Name of the course outcome
CO-1	To acquire the fundamental concepts and principles of engineering process calculations
CO-2	To learn statistical techniques for processing & evaluating biological data
CO-3	To apply hypothesis testing principles to biological data and interpret them
CO-4	To understand the material balance in several unit processes and unit operations
CO-5	To understand the energy balance related to various process used for biological system

6. CO-PO Matrices &CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-2	3	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-3	2	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-4	3	3	1	-	-	-	-	-	-	-	-	-	2	1
CO-5	3	3	1	-	-	-	-	-	-	-	-	-	2	1
Total	14	14	2	-	-	-	-	-	-	-	-	-	12	2
Average	2.8	2.8	0.4	-	-	-	-	-	-	-	-	-	2.4	0.4

1. Name of the Subject: BIOINFORMATICS AND COMPUTATIONAL BIOLOGY LAB

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bioinformatics and Computational Biology Lab	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	80	20

3. Course Content:

1. Overview of biological database
2. Data retrieval practice using NCBI Entrez
3. Finding similar nucleotide sequences using BLASTn, megablast and discontinuous megablast
4. Finding similar protein sequences using BLASTp
5. Finding similar protein sequences using PSI-BLAST, PHI-BLAST, DELTA-BLAST
6. Perform Multiple sequence alignment using MEGA
7. Perform Phylogenetic analysis using different algorithms in MEGA
8. Perform protein structure visualization
9. Molecular docking using Autodock
10. Construct basic programs for bioinformatics using PERL

4. Text/Reference Book

1. *Andreas D. Baxevanis. Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins. Wiley-Interscience*
2. *Mohammed and Mohammed RukunuddinGhalib. Bioinformatics Practical Manual: Basic Bioinformatics Practical*

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	To gain the knowledge of biological database providing the information of biological macromolecules
CO-2	To acquire the knowledge of data mining through various bioinformatics and computational resources
CO-3	To analyze the biological data by dynamic programming and machine learning
CO-4	To visualize the protein structure and it its folding mechanism by various IT resources.
CO-5	To learn the different algorithms and programming language PERL for biological data interpretation

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	1	2	3	-	-	-	2	2	-	1	3	-
CO-2	3	1	1	2	3	1	-	1	1	-	2	1	3	1
CO-3	3	2	1	3	3	2	-	1	2	2	-	1	1	-
CO-4	2	2	1	2	3	1	-	-	2	2	3	-	3	-
CO-5	3	2	-	3	3	2	-	1	1	2	2	2	2	1
Total	13	9	4	12	15	6	-	3	8	8	7	5	12	2
Average	2.6	1.8	0.8	2.4	3	1.2	-	0.6	1.6	1.6	1.4	1	2.4	0.4

SEMESTER-V

1. Name of the Subject: HEAT TRANSFER LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Heat Transfer Laboratory	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	80	20

3. Course Content:

1. To find out heat transfer through lagged pipe.
2. To find the specific heat and thermal conductivity of solid fruits and vegetables.
3. Measurement of specific heat and thermal conductivity of fermentation broth.
4. To find the specific heat and thermal conductivity of gas
5. To find out the overall heat transfer co-efficient for natural and force convection
6. To find the thermal conductivity of Biological tissue
7. To determine the overall heat transfer coefficient in shell and tube heat exchanger
8. To determine over-all heat transfer coefficient in CSTR
9. To find out the heat transfer coefficient in a vertical and a horizontal condenser
10. To find out the heat transfer coefficient of a plate type heat exchanger
11. To find out the Stefan Boltzman's constant and compare with the theoretical value
12. Study and operation of a single effect evaporator
13. To study the unsteady state Heat Transfer

4. Text/Reference Book

1. Ozisik, M. N.: Heat Transfer – A Basic Approach, McGraw-Hill, New York, 1985.
2. Dutta, BK, "Heat Transfer: Principles and Applications", Phi Learning, 2009.
3. Kern DQ, "Process Heat Transfer", Tata McGraw Hill, 2002.
4. Holman JP, "Heat Transfer (in SI Units)", Tata McGraw Hill, 2008

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Estimate heat transfer coefficient in solid fruits and vegetables
CO-2	Estimate the specific heat and thermal conductivity of fermentation broth
CO-3	Estimate the overall heat transfer co-efficient for natural and force convection
CO-4	Estimate the Stefan Boltzman's constant and compare with the theoretical value
CO-5	Estimate the heat transfer coefficient in a vertical and a horizontal condenser

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-2	2	3	3	1	2	-	-	-	-	-	-	-	3	-
CO-3	2	3	3	1	2	-	-	-	-	-	-	-	3	-
CO-4	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO-5	2	3	1	1	2	-	-	-	-	-	-	-	3	-
Total	10	15	11	5	10	-	-	-	-	-	-	-	15	-
Average	2	3	2.2	1	2	-	-	-	-	-	-	-	3	-

SEMESTER-VI

1. Name of the Subject: PROCESS BIOTECHNOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Process Biotechnology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Cell factory design: Microbial, animal and plant cell culture platforms; low cost substrates; Bioprocess design and development from lab to industrial scale; Industrial application of chromatographic and membrane based bioseparation methods, process intensification.

Module 2: Production of biomass, industrial enzymes, Large scale production and purification of recombinant proteins (human insulin, monoclonal antibodies, erythropoietin, vaccines, growth promoting factors, tissue plasminogen activators).

Module 3: Process technology for production of primary and secondary metabolites; antibiotics; Biofuels, Bioplastics, Bioconversion processes; Bioremediation-Aerobic and anaerobic processes for stabilization of solid / liquid wastes; principles of life cycle assessment and bioeconomics

4. Text/Reference Book

1. Ashok Pandey, Rainer Hofer, Mohammad Taherzadeh, et al., 2015. Industrial biorefineries and white biotechnology. Elsevier, 2015, Netherlands
2. Satya N. Mukhopadhyay, Process Biotechnology Fundamentals, Anshan Publishers; 1 edition (April 30, 2004)
3. P T Kalaiselvan, Bioprocess Technology, MJP PUBLISHERS; 1st edition (January 11, 2007)
4. Future Prospects for Industrial Biotechnology, OECD Publishing

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand design of various process for production of primary and secondary metabolites
CO-2	Cell factory design for industrial scale production of primary and secondary metabolites
CO-3	Understand process intensification involved for metabolite production process
CO-4	Understand large scale production and purification process for recombinant proteins.
CO-5	Understand life cycle assessment and bioeconomics

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	**PSO-1**	**PSO-2**
CO-1	2	2	1	1	1	-	-	-	-	-	-	-	2	-
CO-2	2	2	3	2	3	-	-	-	-	-	-	-	2	-
CO-3	2	2	3	2	3	-	-	-	-	-	-	-	2	1
CO-4	2	2	3	3	3	-	-	-	-	-	-	-	2	1
CO-5	2	2	1	1	2	-	-	1	-	-	2	-	2	-
Total	10	10	11	9	12	-	-	1	-	-	2	-	10	2
Average	2	2	2.2	1.8	2.4	-	-	1	-	-	2	-	2	1

SEMESTER-VI

1. Name of the Subject: BIOPROCESS INSTRUMENTATION AND CONTROL

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bioprocess Instrumentation and Control	L	T	P	Mid	End	Internal
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Introduction to automation, process instrumentation, principles of operation, block diagrams, P&I diagrams, revision of Laplace transform, Modeling based on transfer function approach, open-loop systems: dynamic response of first order systems, first order systems in series, second order systems, and transportation lag; Examples for process instruments and control.

Module 2: Process Control:Feedback control, P, PI, PID controllers. Dynamic response of closed loop systems Linear stability analysis: Routh stability criterion, root locus diagrams. Frequency response: Bode diagrams, Nyquist diagrams, Bode and Nyquist stability criterion. Routh analysis; Frequency response - Control system design. Controller tuning: Zeigler-Nichols and Cohen-Coon methods.

Module 3: Control valves, actuators, positioners; Introduction to advanced control: feedforward control, cascade control, dead time compensation, ratio control, internal model control.

Module 4: Modern computer-based control systems: SCADA, PLC, DCS, DDC, illustration of instruments with softwares.

4. Text/Reference Book

1. D. P. Coughnowr, Process Systems Analysis and Control, McGraw Hill, New York, 1991.
2. C. A. Smith and A. B. Corripio, "Principles and Practice of Automatic Process Control", Wiley, New York, 1989.
3. P. Harriot, Process Control, Tata McGraw Hill, New Delhi, 1984.
4. D.P. Eckman, "Industrial Instrumentation", Wiley Eastern Ltd., New York 1990.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Classify instruments for the measurement of pressure, temperature, fluid flow and liquid level.
CO-2	Understand the dynamic behavior of bioprocesses
CO-3	Analyze different components of a control loop
CO-4	Understand the closed loop control system,Sensors and Transducer.
CO-5	Analyze stability of feedback control system

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	1	3	1	-	-	1	-	-	-	-	2	2	1
CO-2	2	2	-	1	-	-	1	-	-	-	-	1	1	-
CO-3	3	2	-	1	-	-	-	-	-	-	-	1	-	-
CO-4	3	2	-	1	-	-	1	-	-	-	-	2	-	-
CO-5	3	2	2	1	-	-	1	-	-	-	-	1	-	-
TOTAL	13	9	5	5	0	0	4	0	0	0	0	7	3	1
AVG	2.6	1.8	1	1	0	0	0.8	0	0	0	0	1.4	0.6	0.2

SEMESTER-VI

1. Name of the Subject: ANIMAL BIOTECHNOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Animal Biotechnology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Cell cycle and cell growth control, Animal cell culture; media composition and growth conditions; Animal cell and tissue preservation;

Module 2: Anchorage and non-anchorage dependent cell culture; Kinetics of cell growth; Micro & macro-carrier culture.

Module 3: Stem cell technology; Animal cloning; Transgenic animals

4. Text/Reference:

1. Culture of animal Cells, A manual of Animal Cells, R.Ian Freshney
2. Principles of Gene Manipulation; S. B. Primrose, R. Twyman, R.W. Old; Wiley-Blackwell; 6th Edition.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Describe the limitations and challenges facing the animal industries and disciplines
CO-2	Describe the various biotechnologies available to the animal related fields
CO-3	Evaluate and discuss public and ethical concerns over the use of animal biotechnology
CO-4	Locate and critically evaluate scientific literature and experimental studies relating to animal biotechnology and be able to effectively communicate the findings in oral and written form.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	2	-	-	2	-	-	-	-	2	3	3
CO-2	3	3	3	2	3	-	-	-	-	-	-	2	3	3
CO-3	-	-	-	-	-	-	3	3	-	-	-	2	3	3
CO-4	-	-	2	-	-	-	-	-	-	3	-	2	3	3
Total	6	6	7	4	3	-	5	3	-	3	-	8	12	12
Average	3	3	2.33	2	3	-	2.5	3	-	3	-	2	3	3

SEMESTER-VI

1. Name of the Subject: DOWNSTREAM PROCESSING LABORATORY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Downstream Processing Laboratory	L	T	P	Mid	End	Internal
Code		0	0	3	-	80	20

3. Course Content:

1. Harvesting of fermentation broth and its processing for product purification.
2. Solid-liquid separation for purification of biomolecules
3. Liquid-liquid separation for purification of biomolecules
4. Disruption of microbial cells by enzymatic or ultrasonic methods
5. Separation of biomolecules in batch and continuous centrifuges.
6. Separation of biomolecules using supercritical fluid extraction
7. Separation of proteins by precipation through adding salts and solvents.
8. Dialysis method for protein purification
9. Separation of biomolecules through cross flow ultra filtration modules.
10. Separation of proteins and other biomolecules by various Chromatography techniques
11. Concentration of biomolecules through Conventional drying, Vaccum evaporation and lyophilization
12. Separation and crystallization of Biomolecules
13. Microbial production and purification of antibiotics
14. Microbial production and purification of enzymes
15. Microbial production and purification of vitamins
16. Microbial production and purification of organic acid

4. Text/Reference:

1. Shuler, M. L., &Kargi, F. (2002). Bioprocess engineering: Basic concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (1984). Principles of fermentation technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical engineering. New York: M. Dekker.
4. Bailey, J. E., &Ollis, D. F. (1986). Biochemical engineering fundamentals. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation microbiology and biotechnology. Boca Raton: CRC/Taylor & Francis.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Extract intra and extra cellular proteins/biomolecules from biological samples
CO-2	Perform cell destruction using a sonicator and enzymatic methods
CO-3	Fractionate proteins using precipitation methods
CO-4	Separate proteins/biomolecules using chromatographic techniques
CO-5	Analyze the purity of protein or biomolecules

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO-1	PSO-2
CO-1	2	3	1	1	2	-	-	-	-	-	-	-	2	-
CO-2	2	3	2	1	2	-	-	-	-	-	-	-	2	-
CO-3	2	3	2	1	2	-	-	-	-	-	-	-	2	-
CO-4	2	3	2	1	2	-	-	-	-	-	-	-	2	-
CO-5	2	3	1	1	2	-	-	-	-	-	-	-	2	-
Total	10	15	8	5	10	-	-	-	-	-	-	-	10	-
Average	2	3	1.6	1	2	-	-	-	-	-	-	-	2	-

SEMESTER-VI

1. **Name of the Subject: IMMUNOTECHNOLOGY LABORATORY**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Immunotechnology Laboratory	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	2	-	80	20

3. Course Content:

Animal Cell Culture Techniques, Estimation and identification of Antigen, Estimation and identification of Antibody, SDS PAGE analysis, Western Blot Techniques, ELISA, ICC, Assay of cellular immunity.

4. Text/Reference:

1. Culture of animal Cells, A manual of Animal Cells, R.Ian Freshney
2. Principles of Gene Manipulation; S. B. Primrose, R. Twyman, R.W. Old; Wiley-Blackwell; 6th Edition.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Able to quantify and identify the antigens and antibodies
CO-2	Able to understand the polyclonal and monoclonal antibodies and their production
CO-3	Able to design different immunological techniques for biotechnology industry

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	-	3	-	-	-	-	-	-	1	1	-
CO-2	3	3	3	-	-	-	-	-	-	-	-	1	2	-
CO-3	3	3	3	-	3	2	3	-	-	-	-	1	3	-
Total	9	9	9	-	6	2	3	-	-	-	-	3	6	-
Average	3	3	3	-	3	2	3	-	-	-	-	1	2	-

SEMESTER-VII

1. **Name of the Subject: ENVIRONMENTAL BIOTECHNOLOGY**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Environmental Biotechnology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Basics of environmental microbiology, metabolism and trophic classification, molecular tools to study microbial ecology

Module 2: Bioremediation: scope and characteristics of contaminants, biodegradability, contaminant availability for biodegradation, engineering strategies for bioremediation, biosorption

Module 3: Treatment of hazardous chemicals: factors causing molecular recalcitrance, biodegradation of problematic environmental contaminants (synthetic detergents, pesticides, hydrocarbons, chlorinated aromatic hydrocarbons, explosives etc.)

Module 4: Biological treatment of water and wastewater, biological nutrient removal (N & P removal)

4. Text/Reference:

1. Environmental Biotechnology: Principles and applications by Bruce E Rittmann and Perry L McCarty.
2. Brock Biology of Microorganisms By Michael T Madigan, John M. Martinko, Paul V. Dunlap, David P. Clark
3. Wastewater Engineering: Treatment and Reuse by Metcalf and Eddy

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Ability to understand the principle of bioremediation
CO-2	Ability to apply engineering skills to solve environmental challenges.
CO-3	Ability to understand the cause, status and ways to reduce pollution.
CO-4	Ability to understand unit operations related to water, wastewater and solid waste treatment.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	1	1	2	3	2	-	-	-	-	3	3
CO-2	3	3	2	1	1	2	3	2	-	-	-	-	3	3
CO-3	3	2	2	1	1	3	3	2	-	-	-	-	3	3
CO-4	3	3	2	1	1	1	3	1	-	-	-	-	3	3
Total	12	12	8	4	4	8	12	7	-	-	-	-	12	12
Average	3	3	2	1	1	2	3	1.75	-	-	-	-	3	3

SEMESTER-VII

1. **Name of the Subject: PLANT BIOTECHNOLOGY**
2. **Credit Structure:**

Course Name		Credit			Marks (Weightage)		
Name	Plant Biotechnology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. **Course Content:**

Module 1: Plant morphogenesis: Special features and organization of plant cells; cellular totipotency; in vitro culture; protoplast isolation and culture; somatic hybridization; haploid and triploid production; somaclonal variation; embryo rescue and synthetic seeds; regeneration of plants, autotrophic and heterotrophic growth; Plant growth regulators and elicitors.

Module 2: Plant cell culture:Outline of plant tissue culture, Cell suspension culture development: methodology, kinetics of growth and production formation, nutrient optimization; Production of secondary metabolites by plant suspension cultures; Hairy root cultures and their cultivation, cryopreservation and conservation of germplasm

Module 3: Plant gene structure and transformation: plant gene structure, function and regulation; plant transformation; marker genes; promoters; Agrobacterium mediated gene transfer –Ti-plasmid-process of T-DNA transfer and integration, transformation in plant, Direct gene transfer methods. Binary vectors, chloroplast transformation.

Module 4: Future Application of plant Biotechnology:Plants as bioreactors, transgenic plants, organic foods, molecular farming, therapeutic products.

4. **Text/Reference:**

a) Plant Biotechnology-The genetic manipulation of plants". A. Slater, N.W.Scott and M. Fowler. Oxford university press, 2003
b) "Plant Molecular Biology: Essential Techniques" P . Jones, P. J. Jones and J. M. Sutton, John Wiley & Sons, 1997.
c) "Plant Tissue Culture: Theory and Practice" S. S. Bhojwani and M. K. Razdan, Elsevier, 1996.
d) "Gene Transfer to Plants"; Potrykus and G. Spangenberg, SpringerVerlag, 1995.

5. **Course Outcomes:**

No. of course outcome	Name of the course outcome
CO-1	To gain the fundamental knowledge of plant cell culture.
CO-2	To understand the concept and principles of plant tissue culture
CO-3	To learn the different strategies of r DNA technology beneficial for crop improvement research
CO-4	To familiarize with the concept of molecular farming by gene manipulation and their scope in agricultural sector
CO-5	To acquire the knowledge of plant derived products useful for society

5. **CO-PO Matrices & CO-PSO Mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	-	-	-	-	-	-	-	-	-	2	3	-
CO-2	3	2	-	-	-	-	-	-	-	-	-	1	2	-
CO-3	2	3	3	3	1	2	1	-	-	-	-	2	3	1
CO-4	2	2	2	3	1	1	2	-	-	-	-	2	3	2
CO-5	2	3	3	3	1	2	1	-	-	-	-	2	3	2
Total	12	12	8	9	3	5	4	-	-	-	-	9	14	5
Average	2.4	2.4	1.6	1.8	0.6	1.0	0.8	-	-	-	-	1.8	2.8	1.0

1. Name of the Subject: BIOPHYSICAL AND BIOANALYTICAL TECHNIQUES

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biophysical and Bioanalytical Techniques	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. **Course Content:**

Module 1: Spectroscopy study of chemical compounds and bio-molecules Electromagnetic radiations and interactions with matters: Absorption of radiation, Beer-Lambert's law, deviation of Beer-Lambert's equation and its limitations. Principals, instrumentation, sampling and application of few spectroscopic techniques: UV-Visible spectroscopy, Fluorescence spectroscopy, IR/Raman spectroscopy, NMR Spectroscopy and Mass spectroscopy.

Module 2: Microscopy: Principals, instrumentation and applications of imaging techniques: Dark-field, Phase contrast, Fluorescence, Confocal microscopy, Atomic force microscopy, and Transmission and Scanning electron microscopy.

Module 3: Diffraction Technique: Crystal geometry and structure: Introduction to lattice and lattice systems, Bragg's plane, miller indices, point groups and space groups Principle of diffraction and X-ray diffraction: X-rays production, X- ray spectra, Bragg's law and intensity of X- rays, Mosley's law, powdered XRD, percentage crystallinity, single crystal XRD, macromolecular XRD (protein crystallization, data collection and structure solution).

Module 4: Gas Chromatography, Introduction to hyphenated techniques in chromatography, GC-MS and LC-MS. Radioisotope techniques Study of radioisotopes in biological samples; Quantification of radioisotopes by proportional and GM counter, scintillation counters; Principles and application of autoradiography and Radioimmunoassay.

4. Text/Reference:

a. I. D. Campbell, Biological spectroscopy (Benjamin/Cummings Pub. Co, Menlo Park, Calif, 1984), Biophysical techniques series.

b. K. Wilson, J. M. Walker, Eds., Principles and techniques of biochemistry and molecular biology (Cambridge University Press, Cambridge, UK : New York, 7th ed., 2009).

c. R. F. Boyer, Biochemistry laboratory: modern theory and techniques (Prentice Hall, Boston, 2nd ed., 2012).

d. R. Katoch, Analytical techniques in biochemistry and molecular biology (Springer, New York, 2011).

e. D. L. Spector, R. D. Goldman, Eds., Basic methods in microscopy: protocols and concepts from cells: a laboratory manual (Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y, 2006).

f. J. R. Lakowicz, Principles of fluorescence spectroscopy (Springer, New York, 2006; http://site.ebrary.com/id/10229235).

g. B. Fultz, Transmission electron microscopy and diffractometry of materials (Springer, Berlin ; New York, 2nd ed., 2002).

h. D. B. Williams, C. B. Carter, Transmission electron microscopy a textbook for materials science (Springer, New York, 2009;

i. R. M. Silverstein, Spectrometric identification of organic compounds (John Wiley & Sons, Hoboken, NJ, 7th ed., 2005).

j. D. Harvey, Modern analytical chemistry (McGraw-Hill, Boston, 2000).

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Advanced knowledge about the interactions of electromagnetic radiation and matter and their applications in spectroscopy and understanding of spectroscopic data collected by the methods discussed in the course.
CO-2	Prepare samples for different types of microscopes while understanding the necessity of such wide range of microscopes.
CO-3	Employ different imaging techniques and may develop new techniques while understanding the applications and principles of physics in imaging techniques.
CO-4	Understand the fundamental principals of different bio-analytical techniques, able to apply the math, science, and engineering knowledge gained in the course to the analysis of biomolecules.

CO-5	Problem solving ability related to the structure, purity and concentration of chemicals and to study molecular interactions by choosing suitable spectroscopic methods and interpreting corresponding data.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High) and for No Correlation :--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	1	1	-	1	-	-	1	-	2	3	3
CO-2	3	1	1	-	2	-	1	1	2	1	1	2	3	3
CO-3	3	3	-	2	2	1	1	1	1	1	-	3	2	2
CO-4	2	2	1	1	2	-	2	-	-	1	-	1	2	3
CO-5	3	3	3	1	1	1	1	2	1	1	1	2	3	3
Total	14	12	8	5	8	2	6	4	4	5	2	10	13	14
Average	3	2	2	1	2	1	1	1	1	1	1	2	3	3

SEMESTER-VII

1. Name of the Subject: PROJECT- I

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Project-I	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	2	-	100	-

3. Course Content: Project Topic

4. Text/Reference:
Journals, Articles and book chapters related to project topics. Students can also access e-sodhsindhu portal.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Students will learn how to execute literature survey and how to define a problem statement.
CO-2	Frame solutions for the problem and to propose a methodology to work for the problem stated with flow chart / planning.
CO-3	Proof of concept, few experiments that can prove the designed solution may work for the problem.
CO-4	Ethical analysis of work, safety, and project finance requirements will be understood.
CO-5	Communicating the findings and prove the concept to be working in the language of Engineering to the panel members.

6. CO-PO Matrices & CO-PSO Mapping of courses:
(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High) and for No Correlation :--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	3	-	3	-	-	-	-	3	-	-	-	-	-
CO-2	3	-	3	-	-	-	-	-	-	-	-	-	3	-
CO-3	-	-	-	3	3	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	3	3	-	-	3	-	-	3
CO-5	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Total	3	3	3	6	3	-	3	3	3	3	3	-	3	3
Average	3	3	3	3	3	-	3	3	3	3	3	-	3	3

SEMESTER-VII

1. Name of the Subject: SEMINAR

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Seminar	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	1	-	100	-

3. Course Content: Seminar topic related to Biotechnology and as per the Summer Training taken up by the students.

4. Text/Reference:
Journals, Articles and book chapters related to project topics. Students can also access e-sodhsindhu portal.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Cover up recent trends and advancements in the field which are out of scope for the curriculum.
CO-2	To communicate and explain the details to large group of people.
CO-3	Preparation of report
CO-4	Collect, analyse, understand, and explain the information on the topic provided.
CO-5	Use of word, powerpoint, latex and other essentials tools.

6. CO-PO Matrices & CO-PSO Mapping of courses:
(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation :--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	3	-	2	-	-	3	-	3	-	-	-	2	3
CO-2	-	-	-	-	-	-	-	-	-	3	-	-	-	-
CO-3	-	-	-	-	2	-	-	3	-	-	-	-	-	-
CO-4	-	-	-	-	-	3	-	-	-	-	-	-	1	-
CO-5	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Total	-	3	-	2	5	3	3	3	3	3	-	-	3	3
Average	-	3	-	2	2.5	3	3	3	3	3	-	-	1.5	3

SEMESTER-VIII

1. Name of the Subject: PROJECT- II

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Project-II	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	3	-	100	-

3. Course Content: Project Topic

4. Text/Reference:
Journals, Articles and book chapters related to project topics. Students can also access e-sodhsindhu portal.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Execute experiments, identify results, analyse, and prepare discussions
CO-2	Use of modern instruments, tools in engineering and IT fields as required.
CO-3	Report preparation
CO-4	Ethical analysis of work, safety, and project finance requirements will be understood.
CO-5	Communicating the findings and presenting to the panel members.

6. CO-PO Matrices & CO-PSO Mapping of courses:
(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High) and for No Correlation :--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	-	-	-	-	3	-	-	-	2	3
CO-2	-	-	-	-	3	-	-	-	-	-	-	-	1	-
CO-3	-	-	-	-	2	-	-	3	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	3	3	-	-	3	-	-	3
CO-5	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Total	3	3	3	3	5	-	3	6	3	3	3	-	3	6
Average	3	3	3	3	2.5	-	3	3	3	3	3	-	1.5	3

SEMESTER-VIII

1. Name of the Subject: COMPREHENSIVE VIVA VOCE

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Comprehensive Viva Voce	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		0	0	1	-	100	-

3. Course Content: Total B.Tech Course Curriculum

4. Text/Reference: All books of B.Tech Course Curriculum

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Evaluate, reasoning, identifying, criticizing, different aspects in the respective field of Biotechnology and Biochemical Engineering.
CO-2	Realize problem stated and relate them to concepts in Biotechnology and Biochemical Engineering

6. CO-PO Matrices & CO-PSO Mapping of courses:
(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	2	-	-	-	-	-	3	3	-	2	-	-
CO-2	3	3	-	2	-	-	-	-	3	3	-	2	-	-
Total	6	5	2	2	-	-	-	-	6	6	-	4	-	-
Average	3	2.5	2	2	-	-	-	-	3	3	-	2	-	-

SEMESTER-VIII

1. Name of the Subject: INDUSTRIAL PROJECT & PROJECT SEMINAR

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
		L	T	P	Mid	End	Internal
Name	Industrial Project	0	0	10	-	100	-
Code		-					
Name	Project Seminar	0	0	02	-	100	-
Code		-					

3. Course Content: Project Topic decided by mainly industry.

4. Text/Reference: Journals, Articles and book chapters related to project topics. Students can also access e-sodhsindhu portal.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Execute experiments, identify results, analyse, and prepare discussions
CO-2	Use of modern instruments, tools in engineering and IT fields as required.
CO-3	Report preparation
CO-4	Ethical analysis of work, safety, and project finance requirements will be understood.
CO-5	Communicating the findings and presenting to the panel members.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	-	-	-	-	3	-	-	-	2	3
CO-2	-	-	-	-	3	-	-	-	-	-	-	-	1	-
CO-3	-	-	-	-	2	-	-	3	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	3	3	-	-	3	-	-	3
CO-5	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Total	3	3	3	3	5	-	3	6	3	3	3	-	3	6
Average	3	3	3	3	2.5	-	3	3	3	3	3	-	1.5	3

DEPARMENTAL ELECTIVE (01)

1. Name of the Subject: THERMODYNAMICS IN BIOLOGICAL SYSTEM

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Thermodynamics in biological system	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module1: scope of thermodynamics, work, heat, state function, paths, equilibrium, first law of thermodynamics, enthalpy, heat capacity, reversible and irreversible processes, application of first law in closed system.

Module2: thermochemistry, application of thermochemistry in biochemical systems, limitations of the first law, heat engine, statements of the second law, entropy (Boltzmann and Clausius), free energy, Maxwell relations, reaction direction and chemical equilibrium, statement of third law.

Module 3: chemical potential and phase equilibria, Clausius Clapeyron equation, thermodynamic properties of mixture (partial molar properties), Gibbs-Duhem relation, fugacity, electrochemical equilibria.

Module 4: bioenergetics, major bioenergetic processes. Application of thermodynamics in metabolic processes, protein stability, DNA hybridization, enzyme-substrate interaction, membrane transport. DONNAN equilibrium.

4. Text/Reference:

1. Biological Thermodynamics by Donald T. Haynie; Cambridge University Press Publication
2. Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience by Dill and Bromberg; Garland Science Publication

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Ability to identify and describe energy exchange processes (in terms of various forms of energy, heat and work) in different chemical and biochemical systems.
CO-2	Ability to apply fundamental concept of thermodynamics to biological and cellular systems.
CO-3	Ability to apply the first Law of Thermodynamics on closed systems
CO-4	Ability to calculate thermodynamic parameters involved in a biochemical reaction.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	2	1	-	-	-	-	-	-	-	3	-
CO-2	3	3	2	2	1	-	-	-	-	-	-	-	3	-
CO-3	3	3	2	2	1	-	-	-	-	-	-	-	3	-
CO-4	3	3	2	2	1	-	-	-	-	-	-	-	3	-
Total	12	12	8	8	4	-	-	-	-	-	-	-	12	-
Average	3	3	2	2	1	-	-	-	-	-	-	-	3	-

DEPARMENTAL ELECTIVE (02)

1. Name of the Subject: IPR AND BIOSAFETY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	IPR and Biosafety	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I: Introduction to Intellectual Property and its types; IPs of relevance to Biotechnology; Important agreements and treaties in general and specific to the field of Bioengineering; handling important databases for IPs.

Module II: Patent: definition and type; National & PCT filing procedure: Time frame, Cost, Precautions while patenting – disclosure/non-disclosure; Patent licensing and agreement Patent infringementmeaning, scope, litigation.

Module III: Safety in therapeutic and diagnostic devices like defibrillator, pacemaker, artificial ventilators, patient monitoring system etc; Safety in biomedical implants and prostheses; Precautions in measurements of different physiological parameters; Safety and protocols in proper storage and maintenance of medical records; computers in health care, responsibility, checklists; biomedical waste management.

Module IV: Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Safety in genetic and tissue engineering research; GMOs & LMOs; protocol of drug administration dosage and radiation dosage. Social and ethical implications of biological weapons.

4. Text/Reference:

1. Bertil Jacobson and Alan Murray, Medical Devices: Use and Safety, Publisher: Churchill Livingstone; 1 edition, ISBN-10: 0443102597, ISBN-13: 978-0443102592.
2. Shayne C. Gad and Marian G. McCord, Safety Evaluation in the Development of Medical Devices and Combination Products, Publisher: CRC; 3 edition, ISBN-10: 1420071645, ISBN-13: 978-1420071641
3. Jose Justiniano and VenkyGopalaswamy, Practical Design Control Implementation for Medical Devices, Publisher: Informa Healthcare; 1 edition, ISBN-10: 1574911279, ISBN-13: 978-1574911275.
4. Shayne C. Gad, Safety Evaluation of Medical Devices, Publisher: CRC; 2 edition, ISBN-10: 082470617X, ISBN-13: 978-0824706173.
5. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
6. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the basic issues of biosafety, bioethics and IPR
CO-2	Follow good laboratory procedures and practices
CO-3	Justify the design of confinement facilities at different Biosafety levels
CO-4	Understand the social and ethical issues related to plant, animal and modern biotechnology.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	1	-	-	-	3	3	3	2	1	3	3	-	3
CO-2	-	-	-	-	-	1	2	3	2	2	1	3	-	1
CO-3	-	-	-	-	-	3	2	1	-	3	2	1	2	2
CO-4	-	-	-	-	-	-	3	2	1	3	2	2	-	1
CO-5	-	-	-	-	-	-	-	2	-	-	-	2	-	2
TOTAL	-	1	-	-	-	7	10	11	5	9	8	11	2	9
AVG	-	0.4	-	-	-	1.4	2	2.2	1	1.8	1.6	2.2	0.4	1.8

DEPARMENTAL ELECTIVE (03)

1. Name of the Subject: METABOLIC ENGINEERING AND SYSTEMS BIOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Metabolic Engineering And Systems Biology	L	T	P	Mid	End	Internal
Code		3	0	0	30	50	20

3. Course Content:

Module I: Introduction to Systems Biology & metabolic engineering, Laboratory techniques used in systems biology studies: Omics technologies; Monitoring and measuring the metabolome: isotope labelling methods, separation-analytical techniques, DNA / phenotypic microarrays and proteomics.

Module II: Mechanistic models for different biochemical processes in cells: Enzyme kinetics, cooperativity, transport systems & kinetics, ODEs& stochastic biochemical kinetics, Lambda phage multistability, synthetic genetic switches, Chemotaxis, genetic oscillators.

Module III: Cellular network reconstruction, Genome scale metabolic models, comprehensive models of cellular reactions with stoichiometry and reaction rates; metabolic flux analysis of exactly/over/under determined systems, sensitivity analysis; Regulatory network models.

Module IV: Metabolic control analysis, control coefficient estimation, summation theorems, Identification of targets for metabolic engineering, pathway editors.

4. Text/Reference:

1. Christinia D Smolke. The Metabolic Pathway Engineering Handbook. Fundamentals. CRC Press, Finland 2010.
2. Christinia D Smolke. The Metabolic Pathway Engineering Handbook. Tools and applications. CRC Press, Finland 2010.
3. Greogory N Stephanopoulos. Metabolic Engineering: Principles and Methodologies. Academic Press, UK, 1998.
4. Oleg Demin, Igor Goryanin. Kinetic Modeling in Systems biology. CRC Press, 2009
5. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Press,Â Mathematical and Computational Biology, 2nd edition, 2006.
6. Zoltan Szallasi, JörgStelling, and Vipul Periwal, System Modeling in Cellular Biology: From Concepts to nuts & bolts. The MIT Press, Massachusetts.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Fundamentals of systems biology and analytical tools required for the system level studies on different cellular factories
CO-2	Mechanistic modeling of complex cellular functions, enzymes and cooperativity.
CO-3	Pathways, Tools, mathematical interventions required for metabolic engineering.
CO-4	Metabolic Control analysis, and pathway manipulation target identifications.
CO-5	Construction, and analysis of systems level and Genome Scale Metabolic models

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	-	-	3	2	-	-	-	-	-	-	-	-
CO-2	3	3	3	3	2	-	-	-	-	-	-	-	-	-
CO-3	2	2		3	3	-	-	-	-	-	-	-	-	-
CO-4	2	2	3	2	2	-	-	2	-	-	-	-	-	2
CO-5	-	-	3		3	-	-	3	-	-	-	-	-	3
Total	9	9	9	8	13	2	-	5	-	-	-	-	-	5
Average	2.25	2.25	3	2.67	2.6	2	-	2.5	-	-	-	-	-	2.5

DEPARMENTAL ELECTIVE (04)

1. Name of the Subject: GENOMICS AND PROTEOMICS

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Genomics and Proteomics	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I:Structural genomics: Overview of Human genome, DNA mapping and sequencing; Map alignment; Large scale sequencing methods (Shotgun and Sanger method); Functional Genomics Analyses: Genome-wide association (GWA) analysis; Comparative Genomic Hybridization (CGH); Serial Analysis of Gene Expression (SAGE); Massively parallel Signature Sequencing (MPSS);

Module II:Pattern of Gene expression: Analysis of alteration in gene expression by differential display and suppression subtractive hybridization, Designing and producing microarrays; types of microarrays; cDNA microarray technology; oligonucleotide arrays; Sample preparation, labelling, hybridization, generation of microarray data. Gene Expression analysis by cDNA and oligonucleotide arrays;

Module III:Tools of Proteomics: Over-View of strategies used for the identification and analysis of proteins; 1-D and 2-D Polyacrylamide Gel Electrophoresis (PAGE) of Proteins, Zymogram; western blotting, DIGE, iTRAQ, MRM techniques.

Module IV: Advanced Proteomics: Mass-Spectrometry in Proteomics, analysis, functional and comparative Proteomics, protein microarray and applications.

4. **Text/Reference:**

a) Richard M. Twyman; 'Principles of Proteomics', Publisher: BIOS Scientific Publishers, ISBN: 978-0815344728

*b) Matthiesen R, 'Mass Spectrometry Data Analysis in Proteomics'; Humana Press 2007; **ISBN:** 978-1-58829-563-7*

c) Terence A Brown., Genomes, 2nd edition; Oxford: Wiley-Liss; 2002. ISBN-10: 0-471-25046-5

d) Pevsner J, Bioinformatics and Functional Genomics, Wiley-Blackwell, ISBN: 978-81-265-3834-8

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	To familiarize the students with the basic concepts of genome structure and its importance in modern research
CO-2	To practicethe versatile techniques, tools and IT resources often used in genome sequencing, assembly and annotation
CO-3	To acquire the knowledge of protein expression and its application in clinical and health sciences.
CO-4	To analyze the complex interaction between genomics and proteomics and their application in current research.
CO-5	To apply the different methodologies, tools and common IT resources used in proteomics

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	2	3	2	1	-	-	-	1	-	2	3	-
CO-2	2	2	2	2	3	-	-	-	-	1	-	1	2	-
CO-3	1	2	3	3	2	3	1	-	-	1	1	2	3	-
CO-4	2	2	2	3	3	2	-	-	-	-	-	1	2	-
CO-5	2	2	3	2	3	1	-	-	-	1	-	2	3	-
Total	8	10	12	13	13	7	1	-	-	4	1	8	13	-
Average	1.6	2.0	2.4	2.6	2.6	1.4	0.2	-	-	0.8	0.2	1.6	2.6	-

DEPARMENTAL ELECTIVE (05)

1. Name of the Subject: PROTEIN STRUCTURE AND ENGINEERING

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Protein Structure and Engineering	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module-I: Introduction to protein structure: Protein structural families: Basic structural principles: amino acids and their conformational accessibilities, Ramachandran Plot; Motifs of protein structures and their packing; Schematic and topology diagrams; Families of protein structures: alpha, alpha/beta, beta, small etc.

Module-II: Protein folding and assembly: Protein folding pathways in prokaryotes and eukaryotes; Single and multiple folding pathways; Protein folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins; Osmolyte assisted protein folding; Structure of chaperones and role of chaperones in protein folding.

Module-III: Protein engineering Strategies: Random and site directed mutagenesis; Various PCR based strategies; Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Protein backbone changes; Antibody engineering; All topics will deal with case studies.

Module-IV: Prediction and design of protein structures Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab-initio method for protein structure prediction; Phage display systems; Structure based drug design and case studies, Rational protein design, Specific examples of enzyme engineering such as Tryesyl t RNAsynthetase, Dihydrofolate reductase, Subtilisin.

4. Text/Reference Book

Protein Structure and Protein Engineering, Winnacker Huber, Publisher: Springer, ISBN: 9783642741753, 3642741754, Edition: 2013

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	To acquire the fundamental knowledge of protein structure and family
CO-2	To analyze the structure of protein and their interaction at cellular level
CO-3	To learn the cutting-edge technologies for protein analysis useful for scientific research
CO-4	To understand the protein folding mechanism and protein stability
CO-5	To design the bioactive lead molecule from given protein sequence beneficial for human health.

6. CO-PO Matrices & CO-PSO Mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	1	-	-	-	-	-	-	-	-	2	3	-
CO-2	3	2	2	-	2	-	-	-	-	-	-	1	3	-
CO-3	2	3	3	3	2	1	-	-	-	-	-	2	3	-
CO-4	3	3	3	2	2	2	-	-	-	-	-	2	2	-
CO-5	2	3	3	3	-	2	1	-	-	-	-	1	3	1
Total	13	13	12	8	6	5	1	-	-	-	-	8	14	1
Average	2.6	2.6	2.4	1.6	1.2	1.0	0.2	-	-	-	-	1.6	2.8	0.2

DEPARMENTAL ELECTIVE (06)

1. Name of the Subject: TISSUE ENGINEERING

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Tissue Engineering**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. **Course Content:**

Module I: Introduction to tissue engineering, Cells as therapeutic Agents with examples, Cell numbers and growth rates, Tissue organization, Tissue Components, Tissue types, Functional subunits. Tissue Dynamics, Dynamic states of tissues, Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis.

Module II: Cellular fate processes, Cell differentiation, Cell migration - underlying biochemical process, Cell division - mitotic cell cycle, Cell death - biological description of apoptosis. Coordination of cellular fate processes - soluble signals, types of growth factors and chemokines, sending and receiving a signal, processing a signal, integrated responses, soluble growth factor receptors, Malfunctions in soluble signaling.

Module III: Cell-extracellular matrix interactions - Binding to the ECM, Modifying the ECM, Malfunctions in ECM signaling. Direct Cell-Cell contact - Cell junctions in tissues, malfunctions in direct cell-cell contact signaling. Response to mechanical stimuli. Measurement of cell characteristics - cell morphology, cell number and viability, cell-fate processes, cell motility, cell function. Cell and tissue culture - types of tissue culture, media, culture environment and maintenance of cells in vitro, cryopreservation. Basis for Cell Separation, characterization of cell separation, methods of cell separation.

Module IV: Biomaterials in tissue engineering - biodegradable polymers and polymer scaffold processing, Growth factor delivery, Stem cells, Gene therapy, Bioreactors for Tissue Engineering, In vivo cell & tissue engineering case studies: Artificial skin, Artificial blood vessels, In vivo cell & tissue engineering case studies: Artificial pancreas, Artificial liver, In vivo cell & tissue engineering case studies: Regeneration of bone, muscle, In vivo cell & tissue engineering case studies: Nerve regeneration.

4. **Text/Reference:**

a. "Tissue Engineering", Bernhard O. Palsson, Sangeeta N. Bhatia, Pearson Prentice Hall Bioengineering.

b. "Nanotechnology and Tissue engineering - The Scaffold", Cato T. Laurencin, Lakshmi S. Nair, CRC Press.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the different types of biomaterials that can be used in tissue engineering applications.
CO-2	Acquire knowledge on complex interaction between biomaterials, cells and signals in biological system.
CO-3	Learn the principles techniques skills and modern engineering tools used in tissue culture and regeneration.
CO-4	Develop student's ability to identify, formulate and adopt engineering solution to unmet biological needs.
CO-5	Able to understand broadly the key topics in tissue engineering.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation :--

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	1	1	1	1	1	-	1	-	2	3	3
CO-2	3	-	1	1	3	-	1	1	2	1	1	2	3	1
CO-3	1	-	1	-	2	1	1	1	1	1	1	-	2	2
CO-4	2	2	1	1	1	-	2	-	-	1	-	1	1	3
CO-5	2	2	2	1	1	1	-	2	-	1	1	2	2	2
Total	11	7	7	4	8	3	5	5	3	5	3	7	11	11
Average	2	2	1	1	2	1	1	1	2	1	1	2	2	2

DEPARMENTAL ELECTIVE (07)

1. Name of the Subject: FOOD PROCESS ENGINEERING

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	**Food Process Engineering**	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I: Chemical constituents of foods, their properties and functions; chemical/biochemical reactions in storage/spoilage/ handling of foods; food safety, quality control and certifications.

Module II: Engineering properties of food material (rheological, thermal, electrical properties); mechanical operations in food processing (material handling, size reduction, mixing).

Module III: Food preservation technologies (addition/removal of heat, removal of moisture, irradiation, fermentation, food additives, high pressure processing, hurdle technology).

Module IV: Case studies of a few specific food processing sectors: cereals, oil seeds, fruits and vegetables, fish, meat, poultry, dairy, beverages, spices and herbs, confectioneries.

Module V: Bioprocess for value added products; genetically modified foods, their regulations and social aspects.

4. **Text/Reference:**

1) William C. Frazier, Dennis C. Westhoff, N.M. Vanitha, " Food Microbiology"
2) Romeo T. Toledo, "Fundamentals of Food Process Engineering"
3) H.K. Chopra, P.S. Panesar., "Food Chemistry"
4) P.S. Panesar, H.K. Sharma, B.C. Sarkar, "Bio-processing of foods"
5) R. L. Henricksons, "Meat, Poultry and Sea Food Technology"
6) N. L. Kent, "Technology of Cereals"
7) GiridhariLal, "Preservation of Fruits & Vegetables"
8) Prescott & Dunn, "Industrial Microbiology"

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Ability to understand the component and nutritional value of food
CO-2	Ability to understand the food preservation technologies
CO-3	Ability to understand the processing involved in various food sectors
CO-4	Ability to understand the importance of food safety and regulations

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	2	2	1	1	-	-		-	-	-	-	3	-
CO-2	3	3	2	1	1	2	2		-	-	-	-	3	-
CO-3	3	3	2	1	1	3	1	1	-	-	-	-	3	-
CO-4	1	1	1	1	1	3	3	1	-	-	-	-	3	3
Total	9	9	7	4	4	8	6	2	-	-	-	-	12	3
Average	2.25	2.25	1.75	1	1	2.66	2	1	-	-	-	-	3	3

DEPARMENTAL ELECTIVE (08)

1. Name of the Subject: PHARMACEUTICAL BIOTECHNOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Pharmaceutical Biotechnology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I: Introduction, Industrial Applications- Biopharmaceuticals Role of r-DNA technology for the production of biopharmaceuticals - applications of PCR - constructing recombinant DNA molecules - vectors and host cells for recombinant DNA – transformants - expression of foreign genes - site directed mutagenesis - cloning of human somatostatin in E. coli - engineering bacteria for industrial production of small valuable organics - Characterization and Bioanalytical Aspects of Recombinant Proteins as Pharmaceutical Drugs.

Module II: Monoclonal antibodies - applications of monoclonal antibodies - generation of monoclonal antibodies – immunization, cell fusion, screening and assays – cloning - cell line characterization - antibody characterization - recombinant antibodies - humanization and deimmunization - antibody fragments and constructs - transgenic mice - production methods - in vivo production - mammalian cell culture - Pre-clinical safety assessment and PK/PD in clinical development of antibody therapeutics, Manufacture, Quality control and Stability of immunological products. Manufacturing process validation, Characterization of rDNA-derived biotherapeutics (Physiochemical characterization, biological activity), process related impurities and contaminants, product related impurities and contaminants.

Module III: Vaccines - Ideal Vaccine - types of modern vaccines - attenuated live vaccines - killed inactivated vaccines - conjugated vaccines - subunit vaccines - protein vaccines - DNA vaccines - lipid and carbohydrate antigen vaccines - recombinant live carriers - vaccine adjuvants - Scientific, Technical and Economic Aspects of Vaccine Research and Development

Module IV: Basic approach to gene therapy - vectors used in gene therapy – adeno and retroviral vectors, additional viral-based vectors – manufacturing of viral vectors - non-viral vectors - gene therapy and genetic disease - gene therapy and cancer - gene therapy and AIDS - anti-sense technology - anti-sense oligonucleotides – advantages and disadvantages of 'oligos' - delivery and cellular uptake of oligonucleotides - synthesis of oligonucleotides - anti-gene sequences and ribozymes - membrane modifying agents - Electroporation

Module V: Monoclonal antibodies as therapeutic agents – Rituximab, Advanced biotechnology products in clinical development –Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte-macrophageCSF, Factor VIIa, Factor IX, Factor VIII, Tissue plasminogen activator, Monoclonal antibodies and engineered Mabs, Somatic Gene Therapy- Nonviral Gene Transfer Systems – Xenotransplanation in Pharmaceutical Biotechnology - Tissue Engineering.

4. **Text/Reference:**

1. Groves, J.M., Pharmaceutical Biotechnology, Taylor and Francis, London, 2nd edition, 2006.
2. Klefenz, H., Industrial Pharmaceutical Biotechnology, Wiley-VchVerlag GmbH, Weinheim, 2nd edition, 2002. 2. Rodney, J.Y., Gibaldi, M, Biotechnology and Biopharmaceuticals, John Wiley, New Jersy, 2nd edition, 2003.
3. Pharmaceutical Biotechnology, Drug Discovery and Clinical Applications. Edited by O.KayserandR.H.M¨uller (2006) Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim.
4. Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley, New Jersy, 2nd edition, 2003.
5. Rodney J Y Ho, MILO Gibaldi, Biotechnology & Biopharmaceuticals Transforming proteins and genes into drugs, 1st Edition, Wiley Liss, 2003.
6. Brahmankar D M, Jaiswal S B, Biopharmaceutics and Pharmacokinetics A Treatise, Vallabh Publisher, (1995, reprint 2008).

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand principles of biotechnology in pharmaceutical product developme
CO-2	Role of r-DNA technology for the production of biopharmaceuticals
CO-3	Identify the challenges faced in development of biologicals and drugs
CO-4	Apply advanced biotechnology methods in novel drug development
CO-5	Review the production processes for biologicals and drugs

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO1	2	2	2	1	1	-	-	-	-	-	-	-	1	1
CO2	2	3	2	1	3	-	-	-	-	-	-	-	2	1
CO3	2	3	2	1	2	-	-	-	-	-	-	-	3	1
CO4	2	3	2	1	2	-	-	-	-	-	-	-	3	-
CO5	2	3	2	2	2	-	-	-	-	-	-	-	1	1
Total	10	14	10	6	10	-	-	-	-	-	-	-	10	4
Average	2	2.8	2	1.2	2	-	-	-	-	-	-	-	2	0.8

DEPARMENTAL ELECTIVE (09)

1. Name of the Subject: BIOLOGICAL WASTE TREATMENT

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biological Waste Treatment	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I: Characterization of waste, waste disposal norms and regulations, stoichiomentry and bacterial energetics of biological treatment, microbial kinetics, reactor types (suspended growth reactors, attached growth reactors)

Module II: Introduction to aerobic suspended growth biological treatment, activated sludge treatment, characteristics of activated sludge, process configurations, aeration systems, bulking and other sludge settling problems, analysis and design of activated sludge, analysis and design of settlers

Module III:

Introduction to aerobic attached growth biological treatment systems, trickling filter, oxygen transfer and utilization, rotating biological contactors, biological nutrient removal

Module IV: Introduction to anaerobic process, anaerobic suspended growth processes, anaerobic sludge blanket process, upflow attached growth processes, downflow attached growth processes

Module V: Advanced wastewater treatment (depth filtration, surface filtration, adsorption, gas stripping, ion exchange), Treatment and disposal of sludge, biological means for stabilization and disposal of solid wastes, Treatment of hazardous and toxic wastes.

4. Text/Reference:

1) Wastewater Engineering: Treatment and Reuse by Metcalf and Eddy

2) Environmental Biotechnology: Principles and applications by Bruce E Rittmann and Perry L McCarty

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Ability to apply engineering skills for biological wastewater treatment
CO-2	Ability to understand the various types of bioreactors used in wastewater treatment
CO-3	Ability to understand unit operations related to biological wastewater treatment
CO-4	Ability to understand the role of microbes in wastewater treatment

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium) 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	1	1	2	3	2	-	-	-	-	3	2
CO-2	3	3	2	1	1	2	3	2	-	-	-	-	3	-
CO-3	3	2	2	1	1	2	3	2	-	-	-	-	3	2
CO-4	3	3	2	1	1	2	3	1	-	-	-	-	3	2
Total	12	11	8	4	4	8	12	7	-	-	-	-	12	6
Average	3	2.75	2	1	1	2	3	1.75	-	-	-	-	3	3

DEPARMENTAL ELECTIVE (10)

1. Name of the Subject: BIOSTATISTICS

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biostatistics	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module I: Fundamentals of statistics in biology; Probability: Permutations; Combinations; Inclusion-exclusion rule; Sampling with and without replacement; Conditional probability: Bayes' theorem; Independence; Descriptive statistics and Random variables; Measures of central tendency; Measures of spread; Higher moments: kurtosis, skewness, Statistical data representation; Discrete random variables: Bernoulli, Binomial, Poisson;Geometric distributions; Continuous random variables: Normal; Exponential distributions; Standard normal distribution.

Module II: Samples and populations; Single- and Double-blind experiments; Point and interval estimates; Sampling distributions: t, chi-square, F distributions; Hypothesis testing: null and alternative hypotheses, decision criteria, critical values, type I and type II errors, Meaning of statistical significance; Power of a test; One sample hypothesis testing: Normally distributed data: z, t and chi-square tests; Binomial proportion testing. Two sample hypothesis testing; Nonparametric methods: signed rank test, rank sum test; Kruskal-Wallis test; Analysis of variance: One-way ANOVA.

Module III: Regression and correlation; Analysis of enzyme kinetic data; Michaelis-Menten; Lineweaver-Burk and the direct linear plot; Logistic Regression; Polynomial curve fitting.

Module IV: Single factor experiments; Randomized block design; Plackett-Burman Design; Comparison of k treatment means; Factorial designs; Blocking and confounding; Response surface methodology.

4. Text/Reference:

1. Hogg R.V. and Tanis E.A.(2001). Probability and Statistical Inference, Prentice Hall International Inc.
2. Kale, B.K. (1999). A first Course on Parametric Inference, Narosa Publishing House.
3. Manly, B. F. (2007). Randomization, Bootstrap and Monte Carlo methods in Biology, Chapman & Hall / CRC.
4. Rohatgi, V.K. and Saleh, A.K.Md.(2001). An Introduction to Probability and Statistics, John Wiley & Sons.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Recognize the importance of data collection and its role in determining scope of inference.
CO-2	Demonstrate a solid understanding of interval estimation and hypothesis testing.
CO-3	Choose and apply appropriate statistical methods for analyzing one or multiple variables.
CO-4	Use technology to perform descriptive and inferential data analysis to interpret statistical results correctly, effectively, and in context.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	-	1	-	-	-	-	-	1	2	1
CO-2	3	3	3	3	-	1	-	-	-	-	-	1	2	1
CO-3	3	3	3	3	3	1	-	-	-	-	-	1	2	1
CO-4	3	3	3	3	3	1	-	-	-	-	-	1	2	1
Total	12	12	12	12	6	4	-	-	-	-	-	4	8	4
Average	3	3	3	3	3	1	-	-	-	-	-	1	2	1

DEPARMENTAL ELECTIVE (11)

1. **Name of the Subject: SYNTHETIC BIOLOGY**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Synthetic Biology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module-I: History, definition, Concepts, standardization of biological parts and hierarchical abstraction, Sequencing and fabrication, multiple conditions for accurate modeling and computer-aided-design (CAD), laboratory highlighting BioBrick cloning and chromoprotein reporters as a methodology in synthetic biology.

Module-II: Modeling: Modular protein assembly, modeling of all biomolecular interactions in transcription, translation, regulation and induction of gene regulatory networks; molecular motifs in a bigger network with upstream and downstream components in living cell.

Module-III: Example of applications: Biological computers, Biosensors, Cell transformation, Designed proteins, Industrial enzymes, Information storage,Materials production, Reduced amino-acid libraries, Space exploration, Synthetic genetic pathways, Synthetic life, Synthetic amino acids, Synthetic nucleotides; Bioethics and security.

4. Text/Reference:

1. Liljeruhm, Josefine; Gullberg, Erik; Forster, Anthony C.Synthetic biology: a lab manual
2. Journal: Synthetic biology, Nature Publisher

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	The ability to understand the various definitions of synthetic biology
CO-2	An understanding of the context of synthetic biology with closely related field such as metabolic engineering and genetic engineering
CO-3	An understanding of the issues and relationships between 'top down' and 'bottom up' approach of synthetic biology
CO-4	An appreciation on how the synthetic biology might impact on aspects of interest to mankind internationally

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	3	2	1	1	-	-	-	1	2	2
CO-2	3	3	3	3	3	2	1	1	-	-	-	-	2	2
CO-3	3	3	3	3	3	1	1	1	-	-	-	-	2	2
CO-4	-	-	3	-	2	3	3	3	1	-	-	-	2	2
Total	9	9	12	9	11	8	6	6	1	-	-	1	8	8
Average	3	3	3	3	2.75	2	1.5	1.5	1	-	-	1	2	2

DEPARMENTAL ELECTIVE (12)

1. **Name of the Subject: VALORIZATION OF BIOMASS**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Valorization of Biomass	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Introduction to valorization, significance of valorization for sustainable management of natural resource, biomass types (food waste, agricultural residues, energy crops and others).

Module 2: Valorization of agricultural residues/energy crops: Source, characterization and composition;Separation of lignin & sugars viaphysical, chemical and enzyme catalysis reactions; cellular factories and technologies (fermentation, catalytic hydrogenation, oxidation, thermal liquefaction, gasification, etc.,) for bioconversion of biomass to form value added chemicals and bioenergy products.

Module 3: Valorization of Food wastes: Source, characterization and composition of food waste, biorefinery development, waste valorization strategies: case studies for recovery of chemicals and bioenergy products from food wastes.

4. Text/Reference:

1. Lignocellulosic Biomass Production and Industrial Applications. ArindamKuila, Vinay Sharma, Wiley & Sons, 2017.

2. Reaction Pathwaysand Mechanismsin ThermocatalyticBiomass Conversion II. Marcel Schalf and Z.Conard Zhang. Green Chemistry and Sustainable Technology. Springer Science, 2016. *ISBN 978-981-287-768-0; DOI 10.1007/978-981-287-769-7*

3. Utilization of By-Productsand Treatment of Waste in the Food Industry. Vasso Oreopoulou and Winfried Russ, Springer Science, 2017. ISBN-10: 0-387-33511-0

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Identify the potential resources for valorization targeted for product generation.
CO-2	Understand valorization of agricultural residues
CO-3	Understand various process and cellular factories utilized in valorization of different biomass residues
CO-4	Understand valorization of food wastes
CO-5	Sustainable utilization of resources for economically feasible products.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	3	-	-	-	-	3	-	-	-	-	-	-	3
CO-2	-	3	-	-	-	-	3	-	-	-	-	-	-	3
CO-3	-	-	3	-	-	-	3	-	-	-	-	-	-	3
CO-4	3	-	-	-	-	-	3	-	-	-	-	-	-	3
CO-5	3	3	3	2	-	-	3	-	-	-	-	-	-	3
Total	6	9	6	2	-	-	15	-	-	-	-	-	-	15
Average	3	3	3	2	-	-	3	-	-	-	-	-	-	3

DEPARMENTAL ELECTIVE (13)

1. **Name of the Subject: BIOPROCESS PLANT DESIGN**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bioprocess Plant Design	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Introduction; general design information, mass and energy, flow sheeting, piping and instrumentation, materials of construction for bioprocess plants, mechanical design of process equipment, vessels for biotechnology applications, design consideration for maintaining sterility of process streams and processing equipment, selection and specification of equipment for handling fluids and solids, selection specification and design of heat and mass transfer equipment used in bioprocess industries, utilities for biotechnology production plants, process economics, bioprocess validation, safety considerations, case studies.

4. Text/Reference:

1. Michael C Flickinger. Upstream Industrial Biotechnology, Volume 2: Equipment, Process Design, Sensing, Control, and cGMP Operations. John Wiley & Sons, 2013; ISBN: 1118131231; 9781118131237
2. Henry C. Vogel, Celeste M. Todaro. Fermentation and Biochemical Engineering Handbook, 2nd edition: Principles, Process Design and Equipment. Elsevier Science, 2008.
3. ChristophWittmann, and James C Liao. Industrial Biotechnology: Products & processes. Wiley_VCH. 2017.
4. Brian McNeil, Linda M. Harvey. Practical Fermentation Technology.John Wiley& Sons. 2008.
5. Ray Sinnott and Gavin Towler; Chemical engineering design, Coulson and Richardson's Chemical Engineering Series, sixth edition

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understandingthe components of a bioprocess plant and their importance
CO-2	Design of working components involved in the bioprocess plant
CO-3	Understand and develop a P & ID-diagrams, its applications in industrial installations with subsequent plant designs
CO-4	Calculate and understand the process economics of various bioproducts
CO-5	Understanding safety, environmental, and ethical considerations involved in industries

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO -3	PO -4	PO-5	PO-6	PO-7	PO-8	PO -9	PO-10	PO-11	PO-12	PSO -1	PSO-2
CO-1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO-2	3	-	3	-	-			-	-	-		-	3	-
CO-3	3	-	3	-	-	3		-	-	-		-	3	-
CO-4	3	3	3	-	-		2	-	-	-	3	-	3	-
CO-5	3	2	3	-	-	3	3	3	-	-		-	3	-
Total	15	3	12	-	-	6	5	3	-	-	3	-	15	-
Average	3	2.5	3	-	-	3	2.5	3	-	-	3	-	3	-

DEPARMENTAL ELECTIVE (14)

1. **Name of the Subject:** **MODELING AND SIMULATION FOR BIOLOGICAL SYSTEMS**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Modeling and Simulation for Biological Systems	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Modeling & simulation basics, principles, applications in biological systems; introduction to various software utilized in modeling and simulation; SBML intro & applications.

Module 2: Modeling of enzyme kinetics and growth in batch, fed batch, semi-batch, repeated fed batch, continuous operational modes with analysis; bioreactor modeling;process simulation.

Module 3: Cell physiology modeling: gene expression modeling, Hodgkin-Huxley equations, receptor-ligand binding, ion channels; and systems level modeling

4. Text/Reference:

1. J. Dunn, E. Heinzle, J. Ingham, J.E. Pfenosil "Biological Reaction Engineering: DynamicModellingFundamentalswithSimulationExamples"WILEY-VCHVerlagGmbH&Co.KGaA,Weinheitn, 2003.

2. Z. Szallasi, J. Stelling, V. Periwal "System Modeling in Cellular Biology: From Concepts to Nuts and Bolts" MIT-Press, 2006.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the modeling principles and basics of simulation
CO-2	Utilize certain software tools for modeling and simulation
CO-3	Design and develop kinetic models for various bioprocess involving enzymes and cells
CO-4	Understand the bioreactor modeling principles
CO-5	Understanding the modeling and simulation principles involved in various biological systems

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	-	3	-	-	-	-	-	-	-	-	-	2	-
CO-2	3	-	3	-	3	-	-	-	-	-	-	-	2	-
CO-3	3	-	3	-	1	-	-	-	-	-	-	-	2	-
CO-4	3	-	3	-	1	-	-	-	-	-	-	-	2	-
CO-5	3	-	3	-	1	-	-	-	-	-	-	-	2	-
Total	15	-	15	-	6	-	-	-	-	-	-	-	10	-
Average	3	-	3	-	1.5	-	-	-	-	-	-	-	2	-

DEPARMENTAL ELECTIVE (15)

1. **Name of the Subject: MOLECULAR BASIS OF DISEASES**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Molecular Basis Of Diseases	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I: Identification, Characterization of Genetic Diseases

- Loss of function effect like Hemoglobinopathies, cystic fibrosis
- Chromosomal Disorders like Autosomal dominant, Autosomal recessive, X-linked dominant, X-linked recessive, Y-linked, Abnormality in Mitochondrial DNA
- Huntington's disease, Duchenne muscular dystrophy etc,

Module II: Identification, Characterization of Infectious Diseases

- Types of infectious agents and Pathogens
- Routes of Infection
- Inflammation and Immune Regulation
- Alterations and modifications of Microenvironment, Host-Pathogen Interaction
- Malaria, Leishmaniasis, Influenza, Hepatitis, Urinary tract infections, Botulism, Tetanus, Diarrhea, Tuberculosis, Leprosy, etc.

Module III: Identification, Characterization of Metabolic Diseases

- Energy & Redox Metabolism
- Cell Membrane Transport & Cell Dynamics
- e.g. Diabetes, Alcoholic and Non-alcoholic livers cirrhosis, Obesity etc.

Module IV: Challenging Disease/Syndrome like AIDS, Cancer, Parkinson, Alzheimer

- Genetic & Epigenetic Pathways of Disease
- Responsible Biochemical Pathway

4. Text/Reference:

1. Signal Transduction and Human Disease, T. Finkel, J. S. Gutkind, Wiley Interscience, 10th Edition, 2003
2. Molecular Biology of the Cell (5th Edition), B. Alberts et al., 2008
3. The Biology of Disease (2001), Edited by Jonathan Phillips, Paul Murray & Paul Kirk, Blackwell Scientific

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Overall understand the molecular processes contributing to diseases.
CO-2	Understand the molecular processes that lead to development of knowledge driving the planning of potential therapeutic strategies.
CO-3	Formulate experimental strategies to identify the molecular basis of an uncharacterized disease
CO-4	An ability to be aware of current status of any diseases.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO -3	PO -4	PO-5	PO-6	PO-7	PO-8	PO -9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	-	3	3	-	-	-	-	-	-	1	2	-
CO-2	3	3	3	3	3	3	-	1	-	-	-	-	2	2
CO-3	3	3	3	3	3	3	-	1	-	-	-	-	2	1
CO-4	3	3	-	-	-	3	1	-	1	-	-	1	2	1
Total	12	12	6	9	9	9	1	2	1	-	-	2	10	4
Average	3	3	3	3	3	3	1	1	1	-	-	1	2	1.33

DEPARMENTAL ELECTIVE (16)

1. **Name of the Subject: DRUG DESIGN AND DEVELOPMENT**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Drug Design and Development	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		2	1	0	30	50	20

3. Course Content:

Module 1: Introduction to drug discovery: What is Drug, Natural Substance as Drug, Criteria for compound act as Drug: Stages of drug discovery, identification and validation, Rational approaches to lead discovery based on traditional medicine: Random screening, Non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observation.

Module 2: Target identification and lead characterization: Protein expression profiles. Brief description of methods for generating protein expression profiles: 2D gel-electrophoresis, 2D LCMS and 2D Mass-spectrometry. Analysis of data from 2D-gel experiments: Tools for analysis for Protein-protein interactions: Methods (phage display, yeast two hybrid technique), Analysis of microarray data for target identification. Combinatorial Chemistry for Lead characterization: 2D and 3D NMR spectroscopy principles, X-ray crystallography for target and lead characterization.

Module 3: Computational biology for drug design: Molecular modelling and Virtual screening, Computer assisted Drug Design (CADD), Quantitative modelling of structure activity relationships (QSAR and 3D-QSAR).

Module 4: Delivery of drug into system: Transport of drugs across biological membranes: Factors affecting drug absorption. Role of intestinal transporters in drug absorption; Bioequivalence; Absorption kinetics: Estimation of pharmacokinetic parameters.

4. Text/Reference:

1. Textbook of Drug Design and Discovery, Third Edition, Tommy Liljefors, Povl Krogsgaard-Larsen, Ulf Madsen
2. Introduction to Proteomics, Tools for the New Biology, Daniel C. Liebler, Humana Press; 2002 edition.
3. Terpenoids against human diseases; Editor: DNROY, Taylor & Francis, First Edition, 2019

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Able to understand the basic concept of pharmaceutical drugs
CO-2	Ability to identification of target and lead, and their characterization
CO-3	To understand the criteria for selection of drugs for the development of Novel drug delivery systems, their formulation and evaluation.
CO-4	To understand various approaches for development of novel drug delivery systems.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO -3	PO -4	PO-5	PO-6	PO-7	PO-8	PO -9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	1	-	-	-	1	1	-	-	-	-	1	2	-
CO-2	3	2	2	1	2	1	-	-	-	-	-	1	2	-
CO-3	3	2	2	1	2	1	1	1	-	-	-	1	2	-
CO-4	3	1	2	1	2	1	1	1	-	-	-	1	2	-
Total	12	6	6	3	6	4	3	2	-	-	-	4	8	-
Average	3	1.5	2	1	2	1	1	1	-	-	-	1	2	-

OPEN ELECTIVE (01)

1. **Name of the Subject: BIOSENSORS**

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biosensors	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module I: Introduction to MEMS, Scaling laws, Dynamics and Transport at the micro and nanoscales, Electrokinetics.

Module II: Photolithography : Hard and Soft lithography; Chemical etching; Ion implantation; Bulk and Surface micromachining ; Nanofabrication Techniques; Fabrication based on self assembly; Micropatterns of self assembled monoplayers (SAMs) ; Micropatterns of cells.

Module III: Sensors , actuators and Pumps in MEMS; Molecular Biology on a Chip ; Point Of Care diagnostics; Problems with microfluidic sample preparation; Chips for genomics and proteonomics ; Cell Based Chips for Biotechnology; BioMEMS for cell biology .

Module IV: BioMEMS application in Tissue Engineering; Microscaffording ; Micropatternedcocultures; stem cell Engineering ; Implantable Microdevices ; Implantable Microelectrodes,; Microtools for surgery.

4. Text/Reference:

1. Fundamentals of BioMEMS and Medical Microdevices ; Steven S. Saliterman.

2. Introduction to BioMEMS ; Albert Foltch.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Have a concept on the scope and recent development of the science and technology of micro-and nano-systems
CO-2	Ability to design the micro devices, micro systems using the MEMS fabrication process.
CO-3	Gain a knowledge of basic approaches for various sensor design
CO-4	Gain a knowledge of basic approaches for various actuator design
CO-5	Students will learn about the use of MEMS in biological field.

6. **CO-PO Matrices & CO-PSO mapping of courses:**

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	1	1	-	3	-	1	-	-	1	-	2	3	-
CO-2	3	3	3	1	2	-	-	-	-	-	-	-	1	-
CO-3	3	2	3	1	2	-	-	-	-	-	-	-	2	-
CO-4	3	2	3	1	2	-	-	-	-	-	-	-	1	-
CO-5	1	2	3	-	1	-	2	-	-	-	-	2	1	-
Total	13	10	13	3	10	-	3	-	-	1	-	4	8	-
Average	2.6	2	2.6	0.6	2	--	0.6	-	-	0.2	-	0.8	1.6	-

OPEN ELECTIVE (02)

1. **Name of the Subject:** COMPUTATIONAL FLUID DYNAMICS IN BIOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Computational Fluid Dynamics in Biology	L	T	P	Mid	End	Internal
Code		2	1	0	30	50	20

3. Course Content:

Module I: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.Overview of Numerical Methods; parabolic elliptic and hyperbolic equations; boundary and initial conditions; Approximate Solutions of DifferentialEquations; Variational Principles.

Module II: Finite difference methods (FDM); different means for formulating finite difference equation; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of FDM; Application of the method in bioengineering.

Module III: Finite volume methods (FVM); different types of finite volume grids; central, upwind and hybrid formulations and comparison for convection-diffusion problem; Properties of discretisation schemes; The quadratic upstream interpolation for convective kinetics (QUICK) scheme. Application of the method in bioengineering.

Module IV: Finite Element Methods (FEM): Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; applications in bioengineering.

Turbulence modeling: Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES; applications in bioengineering.

4. Text/Reference:

1. Moukalled, F., Mangani, L., Darwish, M. The Finite Volume Method in Computational Fluid Dynamics; Springer; 2015.
2. O. C. Zienkiewicz, R. L. Taylor and P. Nithiarasu; The Finite Element Method for Fluid Dynamics (Seventh Edition); Elsevier; 2014.
3. Fletcher, Clive A. J.; Computational Techniques for Fluid Dynamics (Volume-I); Springer; 1988.
4. Fletcher, Clive A. J.; Computational Techniques for Fluid Dynamics (Volume-II); Springer; 1988.
5. H. Versteeg, W. Malalasekra; An Introduction to Computational Fluid Dynamics: The Finite Volume Method Approach, Prentice Hall, 1996.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understanding the mass, momentum and energy equations.
CO-2	Know about numerical methods, boundary and initial conditions, approximate solutions of differential equations, variational principles.
CO-3	Write the formulation of FDM, FEM and FVM method and apply to write the code, design and solve the industrial problems.
CO-4	Generate ideas about grid, model, different types of discretization schemes.
CO-5	Application of the FDM, FEM and FVM method in Bioengineering

6. CO-PO Matrices & CO-PSO mapping of courses:

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	1	1	1	-	-	-	-	-	-	1	3	-
CO-2	3	3	2	3	3	-	-	-	-	-	-	-	3	-
CO-3	3	3	3	3	3	-	-	-	-	-	-	-	3	-
CO-4	3	3	3	3	3	-	-	-	-	-	-	-	3	-
CO-5	3	2	1	2	1	-	-	-	-	-	-	1	3	-
Total	15	13	10	12	11	-	-	-	-	-	-	2	15	-
Average	3	2.6	2	2.4	2.2	-	-	-	-	-	-	0.2	3	-

OPEN ELECTIVE (03)

1. Name of the Subject: BIO-NANOTECHNOLOGY

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Bio-nanotechnology	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. **Course Content:**

Module I: Basics of biology - cell, organelles and nucleic acids as genetic material, Biomacromolecules - Self assembly of proteins, oligonucleotides, amphipathic lipids. Organic & inorganic templates in biological systems (Bone mineralization, silicate deposits). Nanomaterial in biotechnology - nanoparticles, quantum dots, nanotubes and nanowires etc.

Module II: Development of nanobiotechnology - timelines and progress, overview, Biogenic nanoparticles, Stealth nanoparticles, Virosomes and virus-like nanoparticles for gene delivery, Stimuli responsive 'smart' nanosystems. Biosensors- different classes; molecular recognition elements, transducing elements, Applications of molecular recognition elements in nanosensing of different analytes.

Module III: Application of various transducing elements as part of nanobiosensors, Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept, Biological nanoparticles production - plants and microbial. Targeted nano delivery systems – The Trojan horse concept (Passive targeting, Active targeting, External triggers, Internal triggers),

Module IV: Nanobiotechnological applications in health and disease – infectious, genetic and chronic, Stem cells & Nanotechnology – Stimulating tissue regeneration (Importance of nanogeometry, nanochemistry & nanomechanics), Capture-based, Cell-based & Tissue based sensors, Nanoparticles for imaging, Nanobiotechnological applications in Environment and food - detection and mitigation.

4. Text/Reference:

a. Nanobiotechnology: Concepts, Applications and Perspectives (2004), Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.
b. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.
c. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications by Tuan Vo-Dinh, CRC Press.
d. An Introduction to Materials in Medicine. Edited by: Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, Academic Press, 2013.

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Able to correlate the impact of nanotechnology and nanoscience in a global, economic, environmental, and societal context.
CO-2	Accquire a working knowledge in nanotechnology techniques (synthesis, fabrication, characterization) and acquire the ability to use them to solve problems in bioengineering, biomedicine and agricultural / environmental issues.
CO-3	Learn the principles governing the effect of size on material properties at the nanoscale, and perform quantitative analysis.
CO-4	Learn the wide range of applications of nanotechnology and its interdisciplinary aspect.
CO-5	Able to identify career paths at the interface of nanotechnology, biology, environmental and agricultural engineering and medicine.

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	2	3	2	1	1	-	1	-	-	1	-	2	1	3
CO-2	3	1	1	-	3	-	1	1	2	1	1	2	1	1
CO-3	3	-	-	-	2	1	1	1	1	1	-	-	2	2
CO-4	2	2	1	1	1	-	2	1	-	1	-	1	1	3
CO-5	3	2	3	1	1	1	1	2	1	1	1	2	3	3
Total	13	8	7	3	8	2	6	5	4	5	2	7	8	12
Average	3	2	2	1	2	1	1	1	1	1	1	2	2	2

OPEN ELECTIVE (04)

1. Name of the Subject: BIOMATERIALS

2. Credit Structure:

Course Name		Credit			Marks (Weightage)		
Name	Biomaterials	**L**	**T**	**P**	**Mid**	**End**	**Internal**
Code		3	0	0	30	50	20

3. Course Content:

Module 1: Introduction to biomaterials science: a multidisciplinary endeavor, Properties of Biomaterials: Physics and General Concepts, Bonding, interatomic, intermolecular, surface interactions, bulk properties of materials: microstructure, strength, deformation, thermal and optical properties, Surface properties of biomaterials, Characterization of Biomaterials.

Module 2: Metallic biomaterials, Ceramic biomaterials, Polymeric biomaterials, Hydrogels, Composite materials, Biological materials, Fatigue failure, Metallic corrosion, Polymer degradation, Ceramic degradation, Biomaterial calcification.

Module 3: Physical and Mechanical Properties of Biomaterials, Biocompatibility, Biomaterials surface properties: protein adsorption, surface tension, cells and surfaces in vitro, Tissue-material interface: cell/tissue-biomaterials interaction, biological responses to biomaterials, inflammation, wound healing, and the foreign-body response, systemic toxicity and hypersensitivity, Biofilms, biomaterials and device-related infections.

Module 4: Biomaterials Degradation in the Biological Environment, Selected Applications of Biomaterials (Orthopedics, Dental implantation, Tissue engineering, Implants, Devices and Biomaterials, Regulatory compliance, Legal aspects of biomaterials, clinical trials.

4. Text/Reference:

1. Biomaterials Science: An introduction to materials in Medicine. Buddy D. Ratner et al. 3rd edition, 2012.
2. Biomaterials: The Intersection of Biology and Materials Science - Temenoff and Mikos (Pearson Prentice Hall; ISBN 0-13-009710-1), 1st edition (January 12, 2008.
3. Materials Science and Engineering: An Introduction - Callister (John Wiley and Sons; ISBN 0-471-13576-3), 6th edition, 2002.
4. Science and Engineering of Materials - Askland and Phule (Thomson; ISBN 0-534-55396-6), 5th edition, 2005.
5. An Introduction to Tissue-Biomaterial Interactions- Kay C. Dee et al. (Wiley-Liss, 1st edition, 2002).

5. Course Outcomes:

No. of course outcome	Name of the course outcome
CO-1	Understand the fundamental principals in biomedical engineering, material science and chemistry, and how they contribute to biomaterial development and performance.
CO-2	Able to apply the math, science, and engineering knowledge gained in the course to biomaterial selection and design.
CO-3	Able to classify materials into three main classes and describe their structure-property relationships for use in medical applications.
CO-4	Acquire knowledge of what to consider when selecting a material for an implant and their implications.
CO-5	Learn the mechanisms by which the human body reacts to a foreign material

6. CO-PO Matrices & CO-PSO Mapping of courses:

(1: Slight (low), 2: Moderate (Medium); 3: Substantial (High); and for No Correlation: --

CO & PO/PSO mapping	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	-	1		1	-	-	1	-	-	3	3
CO-2	3	1	1	-	3	-	-	1	2	1	1	-	3	1
CO-3	3	-	-	-	2	1	-	1	1	1	-	-	3	3
CO-4	-	2	1	-	1	3	2	1	-	1	-	-	1	-
CO-5	3	2	3	-	1	1	1	2	1	1	1	-	3	-
Total	12	8	8	-	8	5	4	5	4	5	2	-	13	7
Average	3	2	2	-	2	2	1	1	1	1	1	-	3	2