COURSE STRUCTURE

FOR

FOUR-YEAR B.TECH PROGRAMME

IN

BIOTECHNOLOGY

DEPARTMENTOF BIOTECHNOLOGY

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Maha laxmi Vihar, Ghatikia

Bhubaneswar- 751029, Odisha, India

www.outr.ac.in

Ph.No.: 0674-2386075(Off.), Fax:0674-2386182

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar- 751029.

Syllabus Structure (Admission Batch: 2023-24)

School/ Department: Biotechnology

Course: B.Tech., **Programme: Biotechnology**

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				

*Internal Assessment Mark (40marks) consists of (i) Mid Semester (20marks), (ii) Quiz/Assignment/Attendance (20marks)

3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	BS	BH2459	Mathematics–III	3	0	0	3	40	60	-	100
2	PC	BT2101	Cell and Molecular Biology	3	0	0	3	40	60	-	100
3	PC	BT2103	Biochemistry	3	0	0	3	40	60	-	100
4	PC	BT2105	Biostatistics	3	0	0	3	40	60	-	100
5	ACC	CS2111	Object Oriented Programming using C++	3	0	0	2	40	60	-	100
6	HS	BH2437	Organizational Behaviour	3	0	0	2	40	60	-	100
7	LC	BT2501	Biosafety, Bioethics and Biostatistics Laboratory	0	0	3	1.5	-	-	100	100
8	LC	BT2503	Biochemistry Laboratory	0	0	3	1.5	-	-	100	100
9	LC	BT2505	Cell and Molecular Biology Laboratory	0	0	3	1.5	-	-	100	100
10	ACC	CS2511	Object Oriented Programming using C++ Laboratory	0	0	3	1.5	-	-	100	100
Total				**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	BT2102	Microbiology	3	0	0	3	40	60	-	100
2	PC	BT2104	Genetics and Genetic Engineering	3	0	0	3	40	60	-	100
3	PC	BT2106	Bioenergetics and Thermodynamics	3	0	0	3	40	60	-	100
4	PC	BT2108	Bioanalytical Tools and Techniques	3	0	0	3	40	60	-	100
5	ACC	CS2114	Introduction to Artificial Intelligence and Machine Learning	3	0	0	2	40	60	-	100
6	HS	BH2439	Engineering Economics	3	0	0	2	40	60	-	100
7	LC	BT2502	Microbiology Laboratory	0	0	3	1.5	-	-	100	100
8	LC	BT2504	Genetic Engineering Laboratory	0	0	3	1.5	-	-	100	100
9	LC	BT2506	Bioanalytical Techniques Laboratory	0	0	3	1.5	-	-	100	100
10	LC	BT2508	Biological and Biomimetic Materials Laboratory	0	0	3	1.5	-	-	100	100
11	Summer Internship and Research Experience (SIRE-I)*										
Total				**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

*** Minimum 4 weeks of Summer Course/ Training/ Internship/ Skill Course/ etc. after 4th Semester**

5th Semester

Sl. No.	Subject Type	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	PC	BT3101	Plant and Animal Biotechnology	3-0-0	3
2	PC	BT3103	Bioprocess Engineering	3-0-0	3
3	PC	BT3105	Immunology	3-0-0	3
4	(PE)/ (PE)	BT3201/ BT3203	Pharmaceutical Biotechnology / Transport Phenomena in Living Systems	3-0-0	3
5	HS	BH3401/ BH3403	Business Management/ Entrepreneurship Development	3-0-0	2
6	MC	IP3401/ IP3403	Environmental Engineering / Industrial Safety Engineering	3-0-0	2
Subject (Sessional)					
7	PC	BT3501	Bioprocess Engineering Lab	0-0-3	1.5
8	PC	BT3503	Plant and Animal Biotechnology Lab	0-0-3	1.5
9	PC	BT3505	Immunology Lab	0-0-3	1.5
10	PSI	BT3701	Seminar on SIRE – I	0-0-3	1.5
			Total	**18-0-12**	**22**

***Project / Seminar / Internship**

6th Semester

Sl. No	Subject Type	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	PC	BT3102	Bioinformatics	3-0-0	3
2	PC	BT3104	Downstream Process Engineering	3-0-0	3
3	PE PE	BT3202 / BT3204	Food Process Engineering/ Stem Cell Engineering	3-0-0	3
4	PE / PE	BT3206 / BT3208	Biomaterials/ Nanobiotechnology	3-0-0	3
5	HS	BH3403/ BH3401	Entrepreneurship Development/ Business Management	3-0-0	2
6	MC	IP3403/ IP3401	Industrial Safety Engineering/ Environmental Engineering	3-0-0	2
Subject (Sessional)					
7	PSI	BT3602	Project for Product Development – I	0-0-6	3
8	PC	BT3502	Downstream Processing Lab	0-0-3	1.5
9	PC	BT3504	Bioinformatics Lab	0-0-3	1.5
10	Summer Internship and Research Experience (SIRE - II) *				
			Total	**18-0-12**	**22**

***Minimum 4 weeks of Summer Course / Training / Internship / Skill Course / etc. after 6th Semester**

7th Semester

Sl. No.	Subject Type	Subject Code	Subject (Theory)	Contact Hrs. L-T-P	Credit
1	PE / PE	BT4201/ BT4203	Introduction to Systems Biology/ Metabolic Engineering	3-0-0	3
2	PE / PE	BT4205/ BT4207	Marine Biotechnology/ Introduction to Drug Design & Discovery	3-0-0	3
3	OE		Open Elective – I	3-0-0	3
4	ACC	CS4101	Advanced Artificial Intelligence	3-0-0	2
Subject (Sessional)					
3	PSI	BT4701	Seminar on SIRE - II	0-0-6	1
4	PSI	BT4601 / BT4603	Project for Product Development – II / Internship Project - I	0-0-4	2
Total				**12-0-10**	**14**

***Project / Seminar / Internship**

8thSemester

Sl. No.	Subject Type	Subject Code	Subject	Contact Hrs. L-T-P	Credit
1	OE		Open Elective – II	3-0-0	3
2	OE		Open Elective – III	3-0-0	3
3	OE		Open Elective – IV	3-0-0	3
Sessional					
3	PSI	BT4702	Seminar on Project	0-0-6	3
4	PSI	BT4602/ BT4604	Project for Product Development – III / Internship Project - II	0-0-8	4
Total				**9-0-14**	**16**

*** Project / Seminar / Internship**

GRAND TOTAL CREDITS: 162

Syllabus preparation as per NEP

1. Each subject should have pre-requisites (if any), 4 Modules with 30 contact hours as per attached template.
2. Each subject COs, POs & PSOs are to be articulated as per the Blooms Taxonomy.
3. In each subject, at least two Textbooks and relevant Reference books are to be mentioned.
4. In a School, a particular subject offered should have the same course name and content irrespective of departments.
5. Suggest the names of Professional Core (considering the papers in GATE/National level exams syllabus), Professional Elective (considering it as minor specialization) and Open Elective (inter-disciplinary papers) subjects and the associated Labs.

COURSE STRUCTURE

FOR

FOUR-YEAR B.TECH PROGRAMME

IN

BIOTECHNOLOGY

HONOURS

DEPARTMENTOF BIOTECHNOLOGY

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COURSE STRUCTURE FOR HONOURS

Sl. No.	Semester	Course Code	Subject (Theory)	Contact Hrs L-T-P	Credit
1	**5th**	BT3171	Basics of Animal Physiology	3-0-0	3
2	**6th**	BT3172	Biomaterials and Tissue Engineering	3-0-0	3
3	**7th**	BT4171	Genomics, Proteomics & Metabolomics	3-0-0	3
4	**7th**	BT4173	Drug Delivery System	3-0-0	3
5	**8th**	BT4172	Industrial Biotechnology	3-0-0	3
Subject (Sessional)					
6	**6th**	BT3572	Biomaterials and Tissue Engineering Lab	0-0-3	1.5
7	**7th**	BT4571	Biomolecular Modeling & Simulation Lab	0-0-3	1.5

COURSE STRUCTURE

FOR

MINOR DEGREE

IN

BIOMEDICAL ENGINEERING

DEPARTMENTOF BIOTECHNOLOGY

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Maha laxmi Vihar, Ghatikia

Bhubaneswar- 751029, Odisha, India

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COURSE STRUCTURE FOR MINOR DEGREE

IN

BIOMEDICAL ENGINEERING (BME)

(*5th – 8thSEMESTERS*)

Sl. No.	Semester	Course Code	Subject (Theory)	Contact Hrs L-T-P	Credit
1	**5th**	BT3261	Basics of Human Anatomy and Physiology	3-0-0	3
2	**6th**	BT3262	Biomaterials and Tissue Engineering	3-0-0	3
3	**7th**	BT4261	Biomedical Signal Processing	3-0-0	3
4	**7th**	BT4263	Fundamentals of Medical Instrumentation	3-0-0	3
5	**8th**	BT4262	Biomechanics	3-0-0	3
Subject (Sessional)					
6	**6th**	BT3562	Biomaterials and Tissue Engineering Lab	0-0-3	1.5
7	**7th**	BT3561	Medical Instrumentation Lab	0-0-3	1.5

Annexure – I

List of Open Electives to be offered by Department of Biotechnology

Sl. No.	Semester	Course Code	Open Electives Subjects (Theory)	Contact Hrs L-T-P	Credit
1	**7th (OE1)**	BT4301	Nanomedicine and Nanobiotechnology	3-0-0	3
2	**8th (OE2)**	BT4302	Basics of Industrial Biotechnology	3-0-0	3
3	**8th (OE3)**	BT4304	Biology for Engineers	3-0-0	3
4	**8th (OE4)**	BT4306	Biomedical Data Acquisition & Management	3-0-0	3

Syllabus

3rd SEMESTER

CELL AND MOLECULAR BIOLOGY			
Hours/ Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2101**

Prerequisites: Basic knowledge of biology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand the fundamentals of cellular structure, composition and function of living organisms.

CO2: Analyze the mechanisms involved in the cell cycle process and its regulation by apoptosis.

CO3: Explore the molecular organization of DNA and its prokaryotic and eukaryotic replication processes.

CO4: Apply the comprehensive understanding of various mechanisms involved in the cellular processes, *viz.* transcription and translation in both prokaryotes and eukaryotes.

Module-I (Structure and Function of Cellular Components) (8 Hours)

Introduction: Origin and evolution of cells, Cells as experimental models, Cell theory, Organization of Cell (Prokaryotic and Eukaryotic), Cell Wall & Cell Membrane, Nucleus, Endoplasmic reticulum, Golgi apparatus and Lysosomes, Mitochondria, chloroplasts, Peroxisomes, Cell Cycle, Cell Divisions- Mitosis and Meiosis, Programmed cell death, Trasport across membrane, mechanisms of protein sorting and targeting, Overview of cell signaling.

Module-II (Genome Complexity and Central Dogma) (6 Hours)

Genome Organization, Central dogma of molecular biology, Watson- Crick model of DNA, DNA as the genetic material, Kinetics of DNA-DNA hybridization- Genome complexity, C-value Paradox, Denaturation-renaturation, Cot curve analysis, Repetitive DNA. DNA Replication features and essential elements; Semi-conservative DNA replication, Origins of replication in prokaryotes and eukaryotes, Enzymes of DNA replication in prokaryotes and eukaryotes (DNA polymerases), Replication factors

Module-III (Cell Molecular Process - I) (8 Hours)

DNA Replication Mechanism: DNA replication in prokaryotes and eukaryotes, leading strand and lagging strand synthesis, DNA proof-reading. Transcription features and essential components; RNA types- general features, prokaryotic and eukaryotic genes-regulatory elements of genes (proximal or internal, including promoter, operator, activator and enhancers). Controlling factors of Transcription, RNA polymerases of prokaryotes and eukaryotes).

Module-IV (Cell Molecular Process - II) **(8 Hours)**

Transcription: Mechanism of transcriptional initiation, elongation and termination in both prokaryotes and eukaryotes. Post transcriptional m-RNA processing- Capping and poly (A) tailing, m-RNA splicing, mRNA editing. Translation: Genetic code, Codon & anticodon, Principle of protein synthesis, Translation machinery (Activation of t-RNA, Ribosome of prokaryotes and eukaryotes), Mechanism of Translation initiation, elongation and termination in prokaryotes and eukaryotes. Post-translational modification of protein.

Text Books:

1. Geoffrey M. Cooper, The Cell: A Molecular Approach, Sinauer Associates is an imprint of Oxford University Press, 9th Ed., 2022.
2. B. Lewin, Genes XII, International Edition, Pearson Education, 2017.
3. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter, Molecular Biology of Cell, 7th Ed., Garland Publishing, 2022.

Reference Books:

1. Gerald Karp, Cell and Molecular Biology: Concepts and Experiments, 7thedition, Wiley Global Education, 2013.
2. H. Lodish, A. Berk, S. L. Zipursky, M. P. Scott and J. Darnell, Molecular Cell Biology, 9th Ed., W. H. Freeman & Co., 2021.
3. Theory & Problems in Molecular & Cell Biology, Stansfield, Tata-McGraw Hill, 2004.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOCHEMISTRY			
Hours/ Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2103**

Prerequisites: Basic knowledge of biomolecules, cells and cellular metabolism

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Recognizethe basic structures and functions of biomolecules.

CO2: Investigate the chemical properties of biological macromolecules and their relevance.

CO3: Analyze the mechanism and kinetics of enzymatic action, and their regulation.

CO4: Evaluate the significance of major metabolic pathways.

Module-I (Structure and function of Biomolecule-I) (8 Hours)

Amino acids: Classification and properties, Acid–base properties, The Peptide bond, ionization behavior of peptides. Proteins: Levels of protein structure, Determination of primary structure of protein. Secondary, tertiary and quaternary structures, structural patterns: motifs and domains. Ramachandran Plot. Carbohydrates: Classification, configuration and conformation of monosaccharides, sugar derivatives, important disaccharides. Structural and storage polysaccharides, glucosaminoglycans, proteoglycans, glycoproteins and glycolipids.

Module-II (Structure and function of Biomolecule-II) (6 Hours)

Lipids: Classification, storage lipids, structural lipids (glycerol phospholipid and sphingolipids), signaling lipids.Nucleic acid: Nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading upto the proposition of DNA double helical structure; difference in RNA and DNA structure Coenzymes and vitamins: Types and their function.

Module-III (Enzymes and Catalysis) (8 Hours)

Enzymes: General properties, nomenclature and classification, Mechanism of enzyme action: general acid-base catalysis, covalent catalysis, metal catalysis. Enzyme Kinetics: Michaelis-Menten kinetics and its significance, Brigg's-Halden modification, Determination of V_{max} and K_m,Enzyme inhibition: competitive, non-competitive inhibition, determination of KI, allosteric regulation, covalent modification.

Module-IV (Biochemical reactions and metabolism) (8 Hours)

Amino acid catabolism: (transamination, oxidative deamination and urea cycle) Protein degradation (proteosomal pathway) and Solid phase synthesis of peptides. Carbohydrate metabolism: Glycolysis, TCA cycle, pentose-phosphate pathway. Gluconeogenesis, glycogenmetabolism, regulation of carbohydrate metabolism, Oxidative phosphorylation, electron transport and ATP synthesis Lipid metabolism: Biosynthesis and oxidation of fatty acids, regulation of fatty acid metabolism.

Text Books:

1. Lehinger Principle of Biochemistry– D.L. Nelson and M.M. Cox, 8th Ed., 2021
2. Biochemistry byJeremy M. Berg, John L. Tymoczko, Lubert Stryer, W H Freeman & Co; 6th edition, 2006.
3. Fundamentals of Biochemistry– D. Voet, J.G.Voet and C. W. Pratt, 5th Ed., 2015.
4. Biochemistry - U. Satyanarayana and U. Chakrapani, 6th Ed., Elsevier, 2025.

Reference Books:

1. Concise Encyclopedia Biochemistry and Molecular Biology- T. A. Scott and E. I. Mercer, 1996.
2. Biochemistry by Geoffrey Zubay, Brown (William C.) Co ,U.S.,1998.
3. Biochemistry- S. Rastogi, Tata McGraw Hill, 2010.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOSTATISTICS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2105**

Prerequisites: Basic knowledge of mathematics, statistics, and biology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Comprehend the importance of data collection and measure data using central tendency.

CO2: Implement the concept of probability in biological data analysis.

CO3: Applyappropriate statistical methods for analyzing one or multiple variables.

CO4: Investigate a research hypothesis, perform data analysis, and interpret results.

Module-I: (Descriptive Statistics) (8 Hours)

Introduction and definitions of Biostatistics; Concept of variables in biological systems. Collection, Classification, tabulation graphical and diagrammatic representation of numerical data; Measures of central tendency: Mean, Median and Mode and their relationship; Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation, Concept of standard error, Coefficient of variation, Skewness and Kurtosis.

Module-II: (Basic Probability and Probability Distributions) (8 Hours)

Probability: Random experiment, events, sample space, mutually exclusive events, independent and dependent events; Various definitions of probability, addition and multiplication theorems of probability, Random variables (discrete and continuous), Probability density functions and its properties; Probability distributions: normal, Binomial, Poisson and their application, Bayes Theorem, Sensitivity, Specificity.

Module-III: (Sampling of Data and Designing of Experiment) (6 Hours)

Concept of populations and sample. Simple random sampling without replacement. Definition of simple random sample; Designing of Experiments-Random block design and Split plot design.

Module-IV: (Applied Statistics) (8 Hours)

Analysis of variance: One- way and two-way classifications with single observation per cell. Duncan's multiple range test; Tests of significance: Chi-square, student's t-, z- and f-distributions, their properties and uses. Correlation and Regression, linear and quadratic regression.

Text Books:

1. Biostatistics (Health & Life Sciences).By Dr. Rao K. Surya,HimalayaPublishingHouse, 1st Ed., 2010.
2. IntroductiontoBiostatistics &ResearchMethods.BySundarRao PSS& Richard J, PHI learning Pvt. Ltd. 5th.Ed., 2012.
3. MethodsinBiostatistics. ByBKMahajan,Jaypee Brothers,Medical Publishers,India, 2004.
4. Elements of Biostatistics by S. Prasad, Rastogi Publications, 3rd Ed., 2018.

Reference Books:

4. Biostatistics. A foundation for analysis in the health sciences, By Wayne W. Daniel, Wiley-India, 10th Ed., 2013.
5. Biostatistics. By Arora and Mohan, Himalaya Publishing House, 2012.
6. Principles and Practice of Biostatistics. By B. Antonisamy, Prasanna S. Premkumar, Solomon Christopher, Elsevier India., 2013.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOSAFETY, BIOETHICS AND BIOSTATISTICS LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**BT2501**

Prerequisites: basic knowledge of chemistry, enzymatic reactions, and statistics.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Identify the ethical principles, particularly as they apply to biotechnology and biosafety studies.

CO2: Assess and manage risks associated with biological research.

CO3: Implement biosafety measures and ethical decision-making in laboratory settings.

CO4: Interpret results from statistical analyses and correlate their implications in biological research.

List of Experiments

(Any 8 experiments can be done)

Bioethics and Biosafety

1. Handling and disposal of hazardous chemicals, acids, biomedical wastes, radioactive wastes etc.
2. Practical aspects of sterilization and disinfection procedures.
3. Different biosafety level and types of biosafety cabinets.
4. General safety aspects of different instrument handling.
5. Ethical studies of use of animal in laboratory.

Biostatistics

1. Graphical representation of data using Excel, Origin, SPSS etc.
2. Measure of Central Tendency (mean, median, mode).
3. Measure of dispersion (mean deviation, standard deviation, standard error).
4. Correlation and Regression analysis.
5. Analysis of variance (One-way,Two-wayANOVA)

Text books:

1. Introduction to Biostatistics & Research Methods. By Sundar Rao PSS & Richard J, PHI learning Pvt. Ltd.5th Ed., 2012.
2. Methods in Biostatistics. By B K Mahajan, Jaypee Publications.9th Ed., 2018.
3. IPR, Biosafety and Bioethics By D. Goel and S. Parashar, Pearson, 2013.

Reference Books:

1. Biostatistics. A foundation for analysis in the health sciences, By Wayne W. Daniel, Wiley
2. Practical Biotechnology: Principles and Protocols by H. N. Thatoi, S. Dash, and S. K. Das, I K International Publishing House, 2017.
3. Principles and Practice of Biostatistics. By B Antonisamy, Prasanna S. Premkumar, Solomon Christopher, Elsevier India.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOCHEMISTRY LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**BT2503**

Prerequisites: basic knowledge of chemistry, enzymatic reactions

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Prepare standard solutions essential to the biochemistry field for better estimation of biomolecules of interest

CO2: Apply the concept of enzyme kinetics to biological macromolecules.

CO3: Identify and carefully use various optical instruments essential for biomolecule estimation.

CO4: Estimate the biomolecules and report the data in the field of biochemistry & biotechnology research.

List of Experiments

(Any 8 experiments can be done)

1. Preparation of standard solutions (Normality, molarity, molality, mass concentration, mass percentage, ppm etc.)
2. Spectrophotometric estimation of Protein.
3. Spectrophotometric estimation of carbohydrates.
4. Spectrophotometric estimation of nucleic acids.
5. Estimation of iodine Number and Saponification value of fatty acids.
6. Estimation of amino acids.
7. Estimation of vitamin.
8. Enzyme activity assay (Bacterial enzyme).
9. Enzyme activity assay (Plant/Animal enzyme).
10. Determination of K_m and V_{max} of an enzyme catalyzed reaction.

Text Books:

1. Gupta R.C. and Bhargavan S. Practical Biochemistry, CBS Publication, 5th Ed., 2018.
2. David T. Phummer. Introduction of Practical Biochemistry (III Edition).McGraw Hill, 2017.
3. B.S. Rao and V. Deshpande, Experimental Biochemistry, A student companion IK International Pvt. Ltd. (New Delhi), 2005.

Reference Books:

1. Harper's biochemistry 24th edition by R K Murray, D K Granner, P A Mayes and V W Rodwell. Appleton and Lange, Stanford, Connecticut. 1996.
2. Thomas M. Devlin. Textbook of Biochemistry with clinical correlations. Wiley Liss Publishers, 7th Ed., 2010.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

CELL ANDMOLECULARBIOLOGYLABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**BT2505**

Prerequisites: basic knowledge ofbiology and solution preparation

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Report cell organelles, cell division process, and the health of cells

CO2: Identify, differentiate, and count various blood cells.

CO3: Isolate nucleic acids from various biological sources.

CO4: Estimate and analyze nucleic acids by gel electrophoresis

List of Experiments

(Any 8 experiments can be done)

1. Study of mitotic cell division.
2. Study of meiotic cell division.
3. Identification of blood cell types in human blood smear and differential leucocyte count.
4. Counting of cell using hemocytometer.
5. Chromosome analysis by karyotyping.
6. Isolation of DNA from different biological sources (Bacterial, Plant, animal tissues).
7. Isolation of RNA from different biological sources (Bacterial, Plant, animal tissues).
8. Qualitative analysis of DNA and RNA by agarose gel-electrophoresis.
9. Quantitative assessment of nucleic acid by using UV spectrophotometer.
10. DNA fragmentation assay.

Text books:

1. K. Wilson & J. Walker, Practical Biochemistry: Principles and Techniques. (eds) Cambridge University Press, New York, 1995.
2. Essential Molecular Biology: Volume I: A Practical Approach, OUP Oxford; 2nd edition, 2000.
3. Cell Biology: A Laboratory Handbook, Julio E. Celis, Academic Press Inc; 2nd Ed, 2004

Reference Books:

1. Douglas A. Skoog and James J. Leary, Principles of Instrumental Analysis. 4th Edition. Saunders College Publishing, 1992
2. Cell and Molecular Biology Lab Manual, by David Thompson, Createspace Independent Publishing, 2010.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

4th SEMESTER

MICROBIOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2102**

Prerequisites: Fundamental knowledge in biology, chemistry and mathematics

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understandthe basis of microbial taxonomy and understand the basic requirements, tools, and techniques for culturing microbes.

CO2: Analyze microbial metabolism, growth kinetics, and genetics.

CO3: Investigate the characteristics, function, and application of microorganisms in the role of microbes in the food and medical realm

CO4: Implement the relevance of microorganisms in a sustainable environment.

Module-I **(8hours)**

Introduction to Microbial Kingdom- Bacteria, Fungi and Viruses; Classical and Modern approaches of microbial taxonomy. Classification, structural organization and multiplication of bacteria, fungi and Viruses; Methods of Microbiology- Culture media, Sterilization, Establishment of pure culture, Staining and its types, Micrometry, Microscopy & its types, Preservation of microbial (bacterial and fungal) cultures.

Module-II **(8 hours)**

Microbial growth and metabolism: Pattern of bacterial growth, Growth kinetics, Monod's Equation, Synchronous growth, Growth inhibitory substances. Metabolism in bacteria, Energy transduction mechanism in bacteria, Cyanobacteria and nitrogen fixation, Anaerobic respiration.

Module-III **(8 hours)**

Microbial genetics: Organization of bacterial and viral genome, Plasmids and Episomes, Genetic recombination in bacteria (Transformation, Conjugation and Transduction), Genetic analysis in bacteria, DNA repair mechanisms in bacteria, Transposons, Mutation in Microorganisms.

Module-IV **(6 hours)**

Food Microbiology: Types of microbes associated with food spoilage, Food preservation methods; Medical Microbiology: Disease causing bacteria, virus and fungi; Antimicrobial agents, Antibiotics, Disinfectants and Vaccines, Health care associated infections- prevention and control; Environmental Microbiology: Microbiology of water, Air, Soil. Bacteriological analysis of water & water treatment, Microbiology of extreme environments (Halobacteria, Methanogens, Thermophiles), Microbiology of sewage and sludge.

Text Books

1. Prescott's Microbiology: J. Willey, L. Sherwood, C. J. Woolverton, 2011.
2. Brock Biology of Microorganisms, M.T. Madigan, K.S. Bender, D.H. Buckley, W.M. Sattley, D.A. Stahl, 2010.

3. Microbiology: An Introduction, B.R. Funke, C.L. Case, G.J. Tortora, 2013.
4. Microbiology principles and explorations- J.G. Black and L.J. Black, 2004.

Reference Books

1. Principles of Microbiology- G. Sumbali and R.S. Mehrotra, Tata McGraw Hill, 2008
2. Agriculturally Important Microorganisms – B.B. Mishra, S.K. Nayak, A. Pahari, NIPA, New Delhi, 2013
3. Frontiers in Soil and Environmental Microbiology- S.K. Nayak and B.B. Mishra, CRC Press, 2016.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

GENETICS AND GENETIC ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2104**

Prerequisite: Basic knowledge on cell biology and molecular biology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Comprehend Mendelian and non-Mendelian genetics and genetic variation, and inheritance patterns.

CO2: Analyze the process of recombinant DNA Technology and gene cloning.

CO3: Apply the various available tools and techniques in genetic engineering.

CO4: Implement the application of Genetic Engineering methods in various fields.

Module-I: Mendelian and Non Mendelian Genetics: (8 Hours)

Mendelism and its principles, Non-Mendelian Gene Interactions (Co-dominance, Complete dominance, Incomplete dominance, Epistasis). Polygene and Multiple alleles, Linkage, crossing over- Chiasma type theory, Holiday model, non-disjunction, inheritance of X-linked recessive genes and Y-linked genes, Gene environment interaction: Concept of Epigenetics.

Module-II Tools of Genetic Engineering: (8 Hours)

Restriction endonuclease- exo& endo nucleases, Nomenclature, Types, Pattern of cleavage, Ligase and other modifying enzymes, Gene cloning vectors- Plasmid, bacteriophage, cosmid, BAC, YAC. Construction of cDNA library, genomic library.

Module-III Techniques of Genetic Engineering : (6 Hours)

Basic concept of gene cloning, Polymerase chain reaction (PCR) and its applications, Variations in PCR, Yeast two-hybrid assay, DNA micro arrays and Chips - principle and analysis,. DNA Sequencing-chemical degradation and Sanger's Methods, Site directed mutagenesis, Gene knockout strategies; Gene targeting and silencing- RNA interference: Antisense RNA, siRNA and mi RNA. In-vitro transcription and translation; Molecular markers-Types (RFLP, RAPD, AFLP, SCAR, EST)

Module-IV: Application of Genetic Engineering: (8 Hours)

Application of molecular markers, DNA typing, Single Nucleotide Polymorphisms, mapping, DNA finger printing and DNA foot printing. Gene therapy and gene replacement/augmentation; DNA vaccines and rDNA products-production of insulin; Genome projects: Human. Transgenic mice.

Text Books

1. Principles of Genetics" – Robert H. Tamarin
2. Genetics: A Conceptual Approach – Benjamin A. Pierce
3. Molecular Biology of the Gene – James D. Watson
4. Principles of Genetics, Robert Tamarin, Tata McGraw Hill
5. Concepts of Genetics, W.S. Klug and M.R. Cummings, Pearson

Reference Books

1. Gene cloning and DNA Analysis, T A Brown, Blackwell publishing
2. Principle of gene manipulation and genomics, Primrose and Old, Blackwell publishing.
3. Recombinant DNA, James D. Watson, Michael Gilman, W.H. Freeman Publisher
4. Principles and Techniques of Biochemistry and Molecular Biology- K.Wilson, J. Walker., Cambridge University Press.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOENERGETICS AND THERMODYNAMICS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2106**

Prerequisites: Undergraduate mathematics and basic knowledge of biological processes

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Comprehendhow the thermodynamic principles can be applied to biological macromolecules.
CO2:Analyze the concepts of phase equilibria to biochemical reactions involving various biological macromolecules.
CO3: Implement principles of bioenergetics to the metabolic pathways.
CO4: Apply the thermodynamic principles to the biochemical process.

Module-I: (Statistical Thermodynamics) (8 Hours)

Statistical Thermodynamics – Boltzmann distribution and Entropy; Partition functions and Ensembles; calculations using protein and DNA molecules. Estimation of thermodynamic properties using generalized equations of state.Thermodynamics of multi-component mixtures– partial molar properties and excess properties; calculation of excess properties from local composition models.

Module-II: (Phase Equilibria) (8 Hours)

Phase equilibria-vapour-liquid and liquid-liquid equilibria with non-ideal solutions. Chemical reaction equilibria – calculation of equilibrium conversions for single and multiple reactions in homogeneous and heterogeneous systems.

Module-III: (Bioenergetics) (7 Hours)

Bioenergetics: Laws of Thermodynamics, entropy, enthalpy and free energy, standard free energy, chemical equilibrium. Phosphoryl group transfer and ATP.

Energetics of metabolic pathways; coupled-reactions and role in catabolism and anabolism; analysis of photosynthesis and electron transport chain; Thermodynamic analysis of fermentation processes.

Module IV: (Non-equilibrium thermodynamics) (7 Hours)

Introduction to non-equilibrium thermodynamics; Onsager reciprocal relations for coupled flows; biological examples.

Text Books

1. Smith & Vanness, Thermodynamics for Chemical Engineers, MGH,2010.
2. Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology. By Ken
3. Dill, Sarina Bromberg, 2nd Edition, 2010, Garland Science.
4. Biochemical and Engineering Thermodynamics. By Stanley I. Sandler,Chemical,4th Edition, 2006, John Wiley and Sons., 2013.

Reference Books

1. Hougen and Watson, Chemical Process Principles (Part one): 2nd ed, John Wiley., 2004
2. Thermodynamics of Biochemical Reactions. By Robert A. Alberty, 2003, John Wiley and Sons, 2000.
3. J. M. Smith, H. C. Van Ness, M. M. Abbott, B. I. Bhatt, Introduction to Chemical Engineering Thermodynamics, 7th (Indian) edition, McGraw Hill, 2009.

Mapping of Course Outcomes with Program Outcomes (POs)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	1	1	-	-	-	-	-
CO2	3	3	1	-	-	1	1	-	-	-	-	-
CO3	3	3	1	-	-	1	1	-	-	-	-	-
CO4	3	3	1	-	-	1	1	-	-	-	-	-

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOANALYTICAL TOOLS AND TECHNIQUES			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT2108**

Prerequisites: Basic knowledge of microscopy, structure of proteins, DNA, and RNA, and radioactivity.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand various imaging and spectroscopic techniques.

CO2: Analyze various separation strategies like centrifugation, electrophoresis, for the isolation of biomolecules of interest.

CO3: Applythe concept of blotting techniques for the detection of specific biomolecules.

CO4: Implement different radioisotope detection strategies.

Module-I **(7 hrs)**

Principle, instrumentationandapplicationsofimagingtechniques: light,electron,fluorescent, confocal, Atomic force microscopy, and Transmission and Scanning electron microscopy. Principle, instrumentation, sampling and application of few spectroscopic techniques: UV, visible, Circular Dichromism, Infrared, Fourier transformation infrared, Mass spectroscopy, Nuclear magnetic resonance

Module-II **(8 hrs)**

Electrophoretic Techniques: Principle, equipment and process, Agarose gel electrophoresis, horizontal and vertical gel electrophoresis, isoelectric focusing, capillary electrophoresis, native and SDS–PAGE. Blotting techniques: Western, Southern and Northern blotting. Visualization of agarose gel and PAGE. Microarray, Immuno-histochemistry, Microtomy.

Module-III **(8 hrs)**

Centrifugation: high speed and ultra. Working principlesof chromatography: Paper chromatography, Thin Layer Chromatography, Ion exchange, gel filtration, Gas Chromatography, High Performance Liquid chromatography, and Fast protein liquid chromatography.

Module-IV **(7 hrs)**

Radioisotope detection techniques: Introduction to radioisotopes, Fountain pen technique, Gieger-Muller monitor, Solid and liquid scintillation counting, Cerkenov counting, safety measures while handling radioactive elements.

Text Books:

1. Biochemistry laboratory: modern theory and techniques. By R.F. Boyer. Prentice Hall, Boston.
2. Bioinstrumentation by L. Veera kumari, MJP Publishers.

Reference Books:

1. Analytical techniques in biochemistry and molecular biology. By R. Katoch. Springer, New York.
2. Fundamentals of Bioanalytical Techniques and Instrumentation. By Sabari Ghosal, Anupama Sharma Awasthi. PHI Learning

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

MICROBIOLOGY LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**BT2502**

Prerequisites: basic knowledge of chemistry, enzymatic reactions

Course Outcomes:
On successful completion of this course, the students should be able to:

CO1: Isolate microorganisms from various sources such as air, water,soil,milk etc.

CO2: Perform Gram Staining, Capsule staining, Fungal staining and analyse the data.

CO3: Conduct antibiotic sensitivity assays and calculate the zone of inhibition

CO4: Perform biochemical assays of microorganisms, such as Casein hydrolysis, Starch hydrolysis

List of Experiments
(Any 8 can be completed)

1. Media preparation and sterilization (Slant, Stab and Broth culture)
2. Isolation of microorganisms from natural habitats (Air, Water, Soil & Milk)
3. Establishment of pure culture by streak plate and serial dilution method.
4. Staining of microbial sample (Gram Staining, Capsule staining, Fungal staining)
5. Micrometry: Calibration of stage and ocular micrometer and measurement of microbial sample.
6. Microscopy: Study of Compound, Phase contrast and Fluorescence Microscopes.
7. Study the bacterial growth curve using spectrophotometer and viability assessment.
8. Antibiotic assay and estimation of Zone of inhibition.
9. Chemical assay and MIC determination of antibiotics.
10. Biochemical assay of microorganisms (Starch Hydrolysis, Casein Hydrolysis and IMViC test).

Text books:

1. Microbiology A laboratory Manual- J.G. Cappuccino and N. Sherman, 2010.
2. Basic Practical Microbiology – A Manual- : D. Burdass, J. Grainger, J. Hurst, 2017
3. Practical Microbiology-D.R. Arora and B. Arora, 2017.

Reference Books:

1. Laboratory Manual Of Microbiology And Biotechnology- K.R. Aneja, 2016
2. Biotechnology a Laboratory Skills Course- J.K. Brown, 2009
3. Basic Laboratory Methods for Biotechnology:Textbook and Laboratory Reference- L.A. Seidman, C.J. Moore, J. Mowery, 2004.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

GENETIC ENGINEERING LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**2504**

Prerequisites: Basic knowledge on nucleic acid structure, restriction enzyme, vector etc.

Course Outcome:

On successful completion of this course the students should be able to:

CO1: Isolate DNA, RNA from a given biological sample.

CO2: Prepare competent cells and target DNA.

CO3: Design recombinant vectors and primers.

CO4: Perform gel electrophoresis, DNA fingerprinting.

List of Experiments

(Any 8 experiments can be done)

1. Isolation and analysis of plasmid DNA.
2. Restriction enzyme digestion of bacterial genomic DNA.
3. Preparation of target DNA by linker/adapters/alkaline phosphatase treatment for cloning.
4. Ligation of DNA fragment with cloning vector.
5. Preparation of competent cells.
6. Transformation to *E.coli* with recombinant vector.
7. Isolation of recombinants and confirmation of insert DNAi n vector.
8. Primer designing, Amplification of DNA sample by PCR.
9. DNA profiling by RAPD.
10. DNA finger printing assay using RFLP, SNP techniques.

Text books:

1. Practical Techniques in Molecular Biotechnology by Bal Ram Singh and Raj Kumar:.
2. Genetic Engineering: Principles and Methods by Jane K.
3. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology by Andreas Hofmann and Samuel Clokie
4. Practical Biotechnology: Principles and Protocolsby H. N. Thatoi, Supriya Dash, and Swagat Kumar Das

Reference Books:

1. DNA Technology: A Reference Handbook: by David E.
2. Cloning: A Reference Handbook: by David E.
3. Biotechnology in Context: by Galè
4. Genetic Engineering: A Reference Handbook: by Harry LeVine

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOANALYTICAL TECHNIQUES LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**2506**

Prerequisites: Basic knowledge on the principles of microscopy, proteins, DNA, RNA and spectrophotometry, basics of chiral molecules and radio isotopes.

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Operate electron microscope and implement different spectroscopic techniques for protein study.

CO2: Apply gel electrophoresis technique and a viscometer for protein analysis.

CO3: Implement chromatography to isolate and separate compounds from a mixture

CO4: Implement different radioisotope detection strategies.

List of Experiments
(Any 8 experiments can be done)

1. UV-Visible spectroscopy: Spectrophotometric analysis of DNA, protein.
2. Determination of secondary structure of protein by Circular dichroism (CD) spectroscopy.
3. Analysis of biomolecules byTLC.
4. Use of viscometer in protein analysis
5. Protein analysis by 2D-PAGE.
6. Visualization by Confocal, Fluorescence and ElectronMicroscopy.
7. Analysis of biomolecules by HPLC.
8. Operation and demonstration of GC.
9. Demonstration of Differential scanning calorimetry (DSC) for study of physical properties.
10. Determination of functional groups by FTIR

Text Books:

1. Biochemistry laboratory: modern theory and techniques. By R.F.Boyer. Prentice Hall, Boston.2006.
2. Bioinstrumentation by L.Veerakumari, MJP Publishers.2016.

Reference Books:

1. Analytical techniques in biochemistry and molecular biology. By R. Katoch. Springer, New York. 2010.
2. Fundamentals of Bioanalytical Techniques and Instrumentation. By Sabari Ghosal, Anupama Sharma Awasthi. PHI Learning, 2008

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOLOGICAL AND BIOMIMETIC MATERIALS LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**BT2508**

Prerequisites: Basic knowledge of biological materials, types, properties (electrical, mechanical, thermal, chemical), and basics of biomedical devices

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Implement various methods of characterization of biological and biomimetic materials.

CO2: Demonstrate the printing methodology of biomimetic materials and print using 3D printer.

CO3: Analyze and quantify the stress-strain relationships of biological/ biomimetic materials.

CO4: Estimate and evaluate the viscoelastic and other mechanical behavior of functional biomaterials.

List of Experiments

(Any 8 experiments can be done)

1. Properties of Biological materials and Biomimetic materials
2. Study of Stress-Strain Relationships in Biological Soft Tissues
3. Study of the operation and usage of 3D-Printer
4. Experimental estimation of effective elastic modulus of 3D-Printed porous biomaterials.
5. Characterization of Viscoelastic Properties of Biological Tissues
6. 3DAnatomical models of Biological Tissues
7. Mechanical characterization of metallic biomaterials.
8. Mechanical characterization of polymeric biomaterials.
9. Viscosity Measurement
10. Deformation Measurement

Text Books:

1. Text Books J. B. Park and R. S. Lakes, An Introduction to Biomaterials, Springer, 2018
2. J.B. Park, and J.D. Boonzino, Biomaterials: Principles and Application, CRC Press, 2017
3. Y.C. Fung, Biomechanics – Mechanical Properties of Living Tissues, Springer, 1993

Reference Books:

1. D. Dowson and V. Wright, An introduction to Biomechanics of joints and joint replacements, Mechanical Engineering Publications, 1980.
2. Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, Taylor and Francis, 2007.
3. J. Black, Biological Performance of materials, Taylor &Francis.
4. B. D. Ratner, F. J. Schoen, A. S. Hoffman, and J. E. Lemons, Biomaterials Science: An introduction to Materials in medicine, Academic Press.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

5th SEMESTER

PLANT AND ANIMAL BIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT3101**

Prerequisites: Basics of Cell Biology, Botany and Developmental Biology

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Explain the concept of totipotency and describe different plant tissue culture techniques like micropropagation and somatic embryogenesis.

CO2: Describe advanced plant biotechnology methods such as gene transfer, protoplast fusion, and GMOs.

CO3: Comprehend and explain the basics of animal cell culture, culture techniquecell growth, and how to check cell health.

CO4: Apply the principles and explain the applications of animal cell culture techniques in recombinant protein production, stem cell technology, and animal cloning

Module-I: (Foundations of Plant Tissue Culture) (8 Hours)

History of plant tissue culture, Concept of totipotency, Plant tissue culture media and its composition, Role of plant growth regulators, Initiation and Establishment of Culture: Explant preparation, Callus culture, Suspension culture, Single cell culture, Microspore Culture; Micropropagation: Stages of micropropagation; Organogenesis, Somatic Embryogenesis, Artificial Seeds.

Module-II: (Advanced Techniques and Plant Biotechnology Applications) (8 Hours)

Protoplast technology: Haploid production, Somatic hybridization, Use of Bioreactors in plant cell culture (overview). Methods of gene transfer: Physical, Chemical and *Agrobacterium* mediated gene transfer, Terminator seed technology, Application inresistance: Insect and Disease Resistance, Products of genetic transformation: Golden Rice, *Bt* Cotton, Flavr-Savr Tomato

Module-III: (Principles of Animal Cell Biotechnology) (8 Hours)

Equipment and materials for animal cell culture: Culture medium: chemical, physical, and metabolic constituents, Primary cell culture development, Cell line preparation: Chemical and enzymatic disaggregation, Cell growth characteristics and Kinetics, Measurement of viability and Cytotoxicity, Biology and characterization of cultured cells

Module-IV: (Genetic Transformation & Animal Biotech Applications) (6 Hours)

Recombinant protein production: Vaccine production, Single cell protein, Stem Cell Cultures, Animal Cell Culture Applications: Embryonic stem cells and their applications; Organ Culture Technology; Transfection of Animal Cells; Case study of animal cloning

Text Books:

1. Introduction to plant tissue culture by M.K. Razdan
2. Plant Biotechnology by H.S. Chawla.
3. RI Freshney, Culture of Animal Cells, 3rd Edition, Wiley-Liss publication Martin Clynes, (Eds) Animal Cell culture Techniques Springer Publication
4. Butler, M. (2003). Animal cell culture and technology (2nd ed.). Taylor & Francis

Reference Books

1. Plant Tissue Culture: Theory and Practice, Bhojwani. S.S. &Razdan. M.K. Elsevier Science Publishers, New York.
2. A Kumar and SK Sopory, Recent advances in Plant Biotechnology, I.K. International. A Slater et al., Plant Biotechnology, Oxford Univ. Press.
3. In vitro cultivation of Animal cells by C.K. Leach, Butterworth and Heinnmamm Ltd.1994.
4. Pörtner, R. (2007). Animal cell biotechnology: Methods and protocols (2nd ed.). Humana Publishers.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOPROCESS ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT3103**

Prerequisites: Undergraduate mathematics, and basic knowledge on biological processes

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Understand the microbial growth kinetics

CO2: Design a bioreactor.

CO3: Use the instrumentation setupfor bioreactors and their operation.

CO4: Apply the mass transfer techniques for bioprocessing, scale up, control and optimization processes.

Module-I: (7 Hours)

Essential concept of Bioprocessing- structure and functions of various microorganisms, metabolic pathways, enzymes, microbial genetics, kinetics, stoichiometry of growth and product.

Module-II: (8 Hours)

Types of Bioreactors, Batch, Fed-batch and Continuous operation, Airlift, Fluidized bed, wave bioreactor, perfusion and micro bioreactors. Development and Optimization of Bio reactor media. Principle of bioreactor design, multiphase bioreactors, mass and heat transfer; Rheology of fermentation fluids, Aeration and agitation; Media formulation and optimization;

Module-III: (8 Hours)

Kinetics of microbial growth, substrate utilization and product formation; Sterilization of air and media; Concept of ideal and non-ideal reactors: residence time distribution, models of non-ideal reactors, Chemostat with immobilized cells, Chemostat with cell recycle.

Module-IV: (7 Hours)

Introduction to scale-up and scale-Down methodologies for Bioreactors, Modelling and Control of bioreactors- traditional and advanced measurement methods.

Text Books

1. Bioprocess Engineering Principles. By P. M. Doran, 2nd edition. Academic Press.
2. Introduction to Biochemical Engineering. By D. G. Rao. Tata McGraw Hill Education, 2nd Edition
3. Bioprocess Engineering: Basic Concepts. By Shuler. M.L and Kargi. F, 2nd Edition. Pearson.

Reference Books

1. Bioreactors: Design, Operation and Novel Applications; Carl-Fredrik Mandenius
2. Biochemical Engineering Fundamentals by J. Bailly & D. Ollis, McGraw Hill Education; 2nd edition

Mapping of Course Outcomes with Program Outcomes (POs)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	1	1	-	-	-	-	-
CO2	3	3	1	-	-	1	1	-	-	-	-	-
CO3	3	3	1	-	-	1	1	-	-	-	-	-
CO4	3	3	1	-	-	1	1	-	-	-	-	-

*Strength of correlation: 3 – High, 2 – Medium, 1 – Low

IMMUNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT3105**

Prerequisites: Basic knowledge on cell biology, human body systems

Course Outcome:

On successful completion of this course, the students should be able to:

CO1: Understand the structure and function of immune system.

CO2: Explain antigen processing and presentation and molecular basis of antibody production

CO3: Analyze immune regulation, tolerance and immune related diseases

CO4: Evaluate immunesystem dysfunction and modern immunological approaches such as hybridoma technology and vaccination.

Module I: Basic of immune system (8 hour)

The origin of Immunology: Overview and history. Types of Immunity: innate and adaptive immunity, Passive and active immunity, Humoral and cell-mediated immunity. Primary and secondary lymphoid organs: Overview of these organs. Antigens, cells of the immune system: Role of immune cells, immune globulins, antibodies, and the Major Histo-compatibility Complex (MHC).Complement system: Explanation and function.

Module II: Antigen Processing and Antibody Production (8 hour)

Antigen Processing and Presentation: The mechanisms of exogenous and endogenous pathways of processing and presentation of antigens; Synthesis of antibody and secretion: Antibody generation and secretion pathways; Molecular basis of Immunology: Structure and function of antibodies, genetic diversity. Antibody Classes, Monoclonal and poly clonal antibody Antigen-antibody reaction: The principles behind antigen-antibody interactions; Immunoassays - ELISA, RIA, immune-histochemistry; immune-blotting; Flow cytometry; Hybridoma Technology: Overview and uses of hybridoma technology.

Module III: Immune response, Tolerance and Regulation (6 hour)

Immune Response and Tolerance: How the immune system responds and maintains tolerance. Regulation of Immune Response, Graft versus Host Reaction:

Module IV: Dysfunction of the immune system and regulation (8 hour)

Dysfunctions of Immune System: Various dysfunctions affecting the immune system and their impact. Immuno deficiencies and immune proliferative diseases: Understanding deficiencies in immune responses and diseases hypersensitivity, autoimmunity,
Vaccinology: The science and strategies behind vaccines.

Text Books:

1. Immunology: Lydyard, P.M., Whelan, A., Fanger, M.W., 1st Ed., Viva Books.2015
2. Essential Immunology: Roitt, I.M., 9th Ed.(1997) Blackwell Scientific, Oxford,UK.2014.
3. Immunology: Kuby, J. 3rd Ed. (1997) Freeman W. H.,oxford.2008
4. Immunotechnology by AKhan, 2017

Reference Books:

1. Immunology and Immunotechnology by Ashim K. Chakravarty, Oxford University Press
2. A Textbook of Immunology & Immunotechnology by B.Annadurai, S Chand & CO
3. Immunology And Immunotechnology by Pandian M R
4. Textbook of Immunology : including Immunotechnology & Immunotherapy by Immunotechnology by Sneh Lata Arya

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

PHARMACEUTICAL BIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT3201**

Prerequisites: Undergraduate mathematics, and basic knowledge on biological processes

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Explain the concept of drug metabolism and pharmacokinetics

CO2: Understand the Genetic engineering applications in relation to production of pharmaceuticals.

CO3: Importance of Monoclonal antibodies in Industries

CO4: Apply the knowledge in gene therapy

Module-I: (8 Hours)

Rational drug designing, Structure –activity relationships and identification of pharmacophore and auxophore in a lead compound; drug design on the basis of drug target interactions. Therapeutic agents and their uses and economics, Regulatory aspects. Drug metabolism and Pharmacokinetics- Metabolism, Physico-chemical principles, Pharmacokinetics action of drugs on human bodies.

Module-II: (8 Hours)

Brief introduction to Biotechnology with reference to Pharmaceutical Sciences. Enzyme Biotechnology- Methods of enzyme immobilization and applications. Brief introduction to Protein Engineering. Use of microbes in industry. Production of Enzymes- General consideration Amylase, Catalase, Peroxidase, Lipase, Protease, Penicillinase etc

Module-III: (8 Hours)

Production of pharmaceuticals by genetically engineered cells (hormones, interferons, biosimilars). Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics). Techniques for development of new generation antibiotics

Module-IV: (7 Hours)

Treatment-products from recombinant and non-recombinant organisms, Interferons, Antisense therapy, cell penetrating peptides. Gene therapy, Types of gene therapy, somatic virus germline gene therapy, mechanism of gene therapy.

Text Books

1. An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford.
2. Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press

Reference Books

1. The Organic Chemistry of Drug Design and Drug Action; Richard B. Silverman, Elsevier.
2. Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Mapping of Course Outcomes with Program Outcomes (POs)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	1	1	-	-	-	-	-
CO2	3	3	1	-	-	1	1	-	-	-	-	-
CO3	3	3	1	-	-	1	1	-	-	-	-	-
CO4	3	3	1	-	-	1	1	-	-	-	-	-

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

TRANSPORT PHENOMENON IN LIVING SYSTEMS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT3203**

Prerequisites: Fundamental knowledge of basic mechanics, human physiology, ordinary and partial differential equations and numerical methods.

Course Outcomes:

CO1: Understand the physics of heat and mass transfer, and general aspects of transport of bio-fluids, nutrients and biomolecules.

CO2: Identify, formulate, and solve mass transfer problems in biological systems.

CO3: Deconstruct biologically relevant fluid mechanics problems into classical solutions.

CO4: Identify, formulate, and solve diffusion, convection, advection and heat transfer problems in biological systems.

Module I (**6 hours**)

Introduction and rheology: Definition of transport processes; Basic and derived units and nomenclature; Dimensionless numbers; General aspects of rheology, Newton's Law, Non-Newtonian fluids and rheology of fermentation broths. Viscosity measurement. Case study. Review of fluid mechanics, Conservation of mass and momentum, Boundary conditions.

Module II **(9 hours)**

Energy conservation: The energy equation, Diffusion, convection, dissipation; Energy from chemical, biochemical and nuclear reactions, Mass conservation(Solute), Convective and diffusive mass transfer; Steady-state Diffusion, Steady-state Radial Diffusion, Steady-state Diffusion with Reaction Unsteady-state Diffusion Pseudo Steady State Approximation. Molecular basis of diffusion- Diffusion as a random walk, Equation of Continuity, Mass Flux, Mass and Molar Fluxes, Fluxes Under Multiple Driving Forces.

Module III **(9 hours)**

Introduction to fluids, hydrostatics, and conservation of mass, Conservation of momentum for fluids, Newtonian fluids and Navier Stokes, Reynolds number, Poiseuille flow, Porous media, Surface tension, Bernoulli’s equation, Boundary layer, Transitional flows; Rheology and rheometry, Hemorheology; Computational fluid dynamics: Case studies –computational fluid dynamics models of blood flow, Non-linear rheology of blood.

Module IV **(8 hours)**

Heat transfer: Introduction to mechanisms and applications of heat transfer, mode of heat transfer: conduction, convection and radiation; Application of Heat and Mass transfer: Absorption, Distillation principles, phase diagrams and equilibrium curves, non-ideal systems, continuous distillation, McCabe - Thiele method, column operation. Drying principles and operation.

Text Books:

1. Transport Phenomena in Biological Systems - Truskey, Yuan, and Katz, 2nd Edition, Pearson, 2009.
2. Johnson M, Ethier CR. Problems for Biomedical Fluid Mechanics and Transport Phenomena. Cambridge University Press; 2013.

Reference Books:

1. Bird, RB, Stewart, WE, Lightfoot, EN. Transport Phenomena, II edition, John Wiley and Sons, New York. 2001.
2. Jiyuan Tu, Guan-heng Yeoh, Chaoqun Liu,Computational Fluid Dynamics: A Practical Approach, Third Edition, Butterworth-Heinemann, 2018.
3. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition, New Jersey, PHI Publishers, 2010
4. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BUSINESS MANGEMENT (3-0-0)

Program	Stream	Sem.	Subject Name	Subject Code	Credit	L	T	P	Contact Hours
UG	B.Tech	$5^{th}/6^{th}$ Sem	Business Management	BH-3401	3	3	0	0	30

Course Outcomes:

i. Comparing and contrasting efficient functional models of business management by integrating the three core areas such as Finance, Human Resource and Marketing Management.
ii. Executing the Management principles in all the functional areas of business.
iii. Correlating the interrelations and interdependence of the areas of Management in a business organisation.
iv. Assessing the functional and managerial practices in business organisations.

MODULE-1: Management Principles - 8 hours

Management Concepts, Nature and Functions, Management Process and Roles of Managers, Levels of Management and Managerial Skills, Theories of Management – Contributions of F.W.Taylor, Henry Fayol, Elton Mayo, Line and Staff Relationship, Centralisation and Decentralisation, Delegation of Authority , Management thoughts in Modern Trend –Systems Approach

MODULE-2: Financial Management – 8 hours

Concept, Financial function and Role of Financial Managers, Instruments of raising short-term and long-term funds, Capital Structure, Techniques of Project Appraisal, Components of Working Capital, Operating Cycle, Factors affecting requirement of Working Capital.

MODULE-3: Human Resource Management - 7 hours

Nature and Scope of Human Resource Management, Manpower Planning, Recruitment and Selection Methods, Performance Appraisal, Need, Objectives, Modern methods of Appraisals: 720 degree, MBO, Assessment Centre Method, Talent Acquisition, Training Need Analysis, Career Planning, Organisational Citizenship Behaviour.

MODULE- 4: Marketing Management - 7 hours

Concept, Nature, Scope and Importance, Marketing Mix and 7P’s of Marketing, Segmentation, Targeting, Positioning, Factors influencing consumer decision-making, e-marketing and Green Marketing

Reference Books:

1- *Modern Business Organisation and Management*, S.A. Sherlekar, Himalaya Publishing House, 2016.
2- *Essentials of Management*, Stephen P. Robbins, 6th Edition, Pearson, 2010.
3- *Financial Management*, Sheeba Kapil, 1st Edition,Pearson, 2013.
4- *Human Resource Management Text and Cases*, K. Aswathappa, 10th Edition,TMH, 2023
5- *Marketing Management*, Rajan Saxena, 6th Edition, TMH publishing house, 2022.
6- *Principles of Management*, Dipak Kumar Bhattacharyya, 1st Edition, Pearson, 2011
7- *Mgmt (Principles of Management)*, Willium& Tripathy, 1st Edition, Cengage Learning, 2016

CO-PO Mapping

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

ENTREPRENEURSHIP DEVELOPMENT (3-0-0)

Program	Stream	Sem.	Subject Name	Subject Code	Credit	L	T	P	Contact Hours
UG	B.Tech	5th/6thSem	Entrepreneurship Development	BH-3403	2	3	0	0	30

Course Outcomes:

1. Exemplifying the business opportunities, social responsibilities and the support system for setting up an enterprise.
2. Determining stages of Entrepreneurial Process starting from idea generation, developing a business plan and operational aspects of an Enterprise.
3. Appraising the different funding options and Financial Management of an enterprise.
4. Assessing the Start-up management practices like incubation, mentorship and Government initiatives.

MODULE-1: Introduction to Entrepreneurship - 8 hours

Concept, Functions of an Entrepreneur, Entrepreneurial Process, Entrepreneurial Motivation and Barriers, Traits to be a successful Entrepreneur, Creativity and scope of Entrepreneurship in India: Types of new age business (FinTech, EdTech, Healthcare, Agripreneurship, Defence, Drone, Space, IT, Robotics, Digital Transformation, Women-Entrepreneurship, Social Entrepreneurship, Corporate Social Responsibility, Business Ethics – Role of Values in Management.

MODULE-2: Entrepreneurial Idea into Action - 8 hours

Developing a Business Idea; Opportunity, Methods and Creativity, Deciding to set up a start-up, Forms of business organisations (Sole tradership/propreitorship, Partnership, Joint-Stock Company) and MSMEs (Micro, Small and Medium enterprises), Size and Location of the enterprise, Feasibility Study: Market Survey, Techno-economic feasibility and preparing a Project Report.

MODULE-3: Entrepreneurial Finance and Funding - 7 hours

Sources of funding(Bootstrapping, Angel Investors, Venture Capital, Crowdfunding etc.) Project Investment Analysis, Break-Even Analysis, ROI Analysis, Basics of Income Statement and Balance Sheet.

MODULE- 4: Managing an Enterprise – 7 hours

The Start-up ecosystem, Business Incubators, Start-up Accelerators, Mentorship and Networking, Failure and Resilience, Risk Management, Ethical dilemmas and Exit Strategies, Start-up Policy and Initiatives of the Government.

Reference Books:

1. *Entrepreneurship: Successfully Launching New Ventures*, B.R. Barringer, 6th, Pearson, 2020
2. *Fundamentals of Entrepreneurship and Project planning*, Madhurima Lall, 1st, Sultan Chand & Sons, 2021
3. *Entrepreneurial Development,*S.S. Khanka, 1st Edition, S Chand and Company, 1999
4. *Entrepreneurship Development and Small business enterprises,* P.M. Charantimath, 3rd Edition, Pearson, 2019
5. *Entrepreneurship: Theory, Process and Practice,* Donald F Kuratco, 11th, Cengage, 2023
6. *Entrepreneurship*, Robert. D. Hisrich & Sabyasachi Sinha, 11th Edition, TMH, 2020

CO-PO Mapping

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

ENVIRONMENTAL ENGINEERING - Subject Code IP 3401					
CREDIT	2		L-3	T-0	P-0
PREREQUISITES: Basic Physics, Basic Chemistry					
COURSE OUTCOMES At the end of the course a student will be able to					
CO1	Understand the multidisciplinary nature of environmental science and ecosystem structure and functions				
CO2	Analyze various forms of environmental pollution and assess their impact using scientific parameters				
CO3	Demonstrate knowledge of water and wastewater treatment processes and air pollution control technologies				
CO4	Evaluate the role of environmental policies, EIA, and sustainable practices in pollution control and resource conservation				
CONTENT					
Module 1 (10 hours)	**Fundamentals of Environment and Ecosystem:** Multidisciplinary nature of environmental Engineering. **Study of Ecosystem:** Definition, Properties, Structure and Function of an ecosystem. Food chains, food webs, Flow of Energy, Ecological Pyramids, Biogeochemical cycles, Types of ecosystems, Bioaccumulation, Bio magnification, ecosystem value, Degradation of Ecosystem. **Concept of Environment and pollution:** Atmospheric chemistry, soil chemistry, water quality characteristics, DO, BOD and COD, water pollution, Marine Pollution, soil pollution, thermal pollution, nuclear hazard, Air Pollution: Air Quality, cause and effects of air pollution, Water and air quality standards, and Index, Noisepollution: Introduction, Noise standards, measurement, Ln Concept and control				
Module 2 (8 hours)	**Water treatment process**: Pre-treatment of water, conventional process, advanced water treatment process. **Waste water treatment process**: Natural Treatment, Engineering Treatment -Pre-treatment, primary and secondary waste water treatment process **Air Pollution Control**: The natural self-cleansing properties of Environment, Air pollution meteorology, Atmospheric dispersion, Diffusion equation, ground level emission, plume rise, Effective stack height, Air Pollution control from stationarysources by installing Engineering devices, Flue gas desulphurisation, NOX removal.				
Module 3 (8 hours)	**Solid waste management:** Source, classification, separation, storage and transportation of solid wastes, Waste minimization techniques, Benefits of waste minimization, reuse, recycle, thermal and biological treatment, secure land fill technique. **Impact of Environmental pollution and related issues:** Global climate change,				

	global warming and greenhouse gases, Acid rain, ozone layer depletion, healthissues.
Module4 (4 hours)	**Environmental Impact Assessment:** EIA procedure, Preparation of an EIS From unsustainable to sustainable development, circular economy, Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Preventionand Control of Pollution) Act, Wildlife Protection Act.
TEXTBOOKS	
1.	Fundamentals of Ecology, M.C.Dash, Tata McGraw Hill, 2006.
2.	Environmental Pollution Control Engineering, C.S. Rao, New Age International Publishers, 2018
3.	Environmental Engineering, G. Kiely, TMH, 2007
REFERENCES	
1.	Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous, McGraw Hill.
2.	Introduction to Environmental Engineering and Science, G.M. Masters, Pearson, 2015
3.	Integrated Solid Waste Management, G. Tchobanoglous, McGraw Hill, 2014
4.	Water Supply Engineering, S.K. Garg; Khanna Publishers, 37th Edition

CO-PO-PSO MAPPING

COs	**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	3	2	1	1	1	2	3	1	1	2	1	2	2	2
CO2	3	3	2	2	2	2	3	1	1	2	1	2	2	2
CO3	3	3	3	2	2	2	3	1	2	2	2	3	3	3
CO4	2	2	2	2	1	3	3	2	2	2	2	3	3	3

Correlation Level 1: Slight 2: Moderate 3: High

INDUSTRIAL SAFETY ENGINEERING- Subject Code: IP3403					
CREDIT	3		L-3	T-0	P-0
PREREQUISITES: NA					
COURSE OUTCOMES At the end of the course a student will be able to					
CO1	Apply safety principles in various work environments, especially in construction and machine operations.				
CO2	Identify safety hazards, implement safety measures,				
CO3	Analyse risks to prevent accidents and injuries.				
CO4	Understand of safety protocols, policies, and the responsibilities of individuals and organizations in ensuring a safe working environment.				
CONTENT					
Module 1 (6 hours)	**Safety Introduction:** Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.				
Module 2 (7 hours)	**Personal Protection in work environment:**Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.				
Module 3 (7 hours)	**Safety issues in Construction:** Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.				
Module4 (12 hours)	**SafetyHazardsinMachines and Hazardidentificationandanalysis:** Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices.Safetyinturning,andgrinding.WeldingandCutting-SafetyPrecautionsofGas welding and Arc Welding. Material Handling-Classification-safety consideration-manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance.				

	Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identificationofhazards:Inventoryanalysis,Fireandexplosionhazardratingofprocessplants The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operabilitystudy(HAZOP))–methodology,criticalityanalysis,correctiveactionandfollow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).
TEXTBOOKS	
1.	R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2.	Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
3.	Krishnan, N.V. (1997).Safety management in Industry. Jaico Publishing House, New Delhi.
REFERENCES	
1.	John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.
2.	Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.
3.	Alan Waring. (1996). Safety management system. Chapman & Hall, England.
4.	Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai

CO-PO-PSO MAPPING

COs	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	3	3	3	2	2	2		3					3	2
CO2	3	3	3	2				3	2				3	2
CO3	3	3	3	2				3					3	2
CO4	2	2	1	2		3		3	2	2			2	2

Correlation Level 1: Slight 2: Moderate 3: High

BIOPROCESS ENGINEERING LAB			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Professional Core**	**Course Code:**	**BT3501**

Prerequisites: Undergraduate mathematics, and basic knowledge on biological processes

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Design of optimal Batch and Continuous reactors

CO2: To learn about submerged culture fermentation in lab scale.

CO3: Evaluate the variables affecting the production process.

CO4: To learn about cell immobilization by entrapment method

List of Experiments

(Any 8 experiments can be done)

1. Bioreactor operation –Demonstration
2. Batch, fed batch and continuous cultures a) Estimation of Monodparameters b) Pure and mixed cultures.
3. Temperature effect on growth-estimation of energy of activation andArrhenius constant for micro-organisms.
4. Production of secondary metabolites by feed batch culture.
5. Parameter optimization studies in bioprocesses
6. Heat inactivation of microbial cells, thermal death rate
7. Kinetic Studies in Batch Reactor
8. Production of Bakers yeast by fermentation
9. Cell Immobilization by entrapment method
10. Immobilized bioprocess with cells and enzymes

Text Books

1. Handbook of Bioseparations. By Satinder Ahuja, Academic Press, 1st Ed., Vol 2, 2000.
2. Practical Biotechnology: Principles and Protocolsby H. N. Thatoi, Supriya Dash, and Swagat Kumar Das

Reference Books

1. Laboratory Protocols in Applied Life Sciences. By Prakash S Bisen, CRC Press, 2014

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

PLANT AND ANIMAL BIOTECHNOLOGY LAB			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Core**	**Course Code:**	**BT3503**

Prerequisites: Basic knowledge on biology and solution preparation

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Demonstrate the preparation and sterilization of plant and animal tissue culture media and explain the role of different media components.

CO2: Perform basic plant tissue culture techniques such as surface sterilization, callus induction, organogenesis, and suspension/anther culture.

CO3: Carry out animal cell culture techniques including primary cell culture, subculturing, and cryopreservation.

CO4: Assess cell growth and viability in cultured cells using standard methods and interpret the results.

List of Experiments

(Any 8 experiments can be done)

1. Introduction to plant tissue culture lab.
2. Preparation and sterilization of plant tissue culture media.
3. Surface sterilization of plant explants.
4. Callus induction from explants.
5. Suspension culture and/ anther culture
6. Organogenesis- shoot and root induction
7. Introduction to animal cell culture lab
8. Preparation of animal tissue culture media and sterilization
9. Primary cell culture technique
10. Cell line subculturing (passaging cells)
11. Measuring cell viability and cytotoxicity
12. Cryopreservation and thawing of animal cells.

Text books:

1. "Experiments in Plant Tissue Culture" By John H. Dodds and Lorin W. Roberts
2. "Practical Manual of Plant Biotechnology" By A. K. Gupta
3. "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications" By R. Ian Freshney
4. "Basic Cell Culture Protocols" (Methods in Molecular Biology) Edited by Cheryl D. Helgason and Cindy L. Miller

Reference Books:

1. "Plant Tissue Culture: Theory and Practice" By S.S. Bhojwani and M.K. Razdan
2. "Animal Cell Culture: A Practical Approach" Edited by John R. W. Masters

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

IMMUNOLOGY LAB			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Laboratory Course**	**Course Code:**	**BT3505**

Prerequisites: Basic knowledge on antibody antigen structure and immune system

Course Outcomes :

On successful completion of this course, the students should be able to:

CO1: Understand the principles and applications of antigen-antibody interactions in immunodiagnostic techniques.

CO2: Perform various immunodiffusion and immunoelectrophoresis techniques for antigen and antibody analysis.

CO3: Demonstrate proficiency in ELISA and ELISPOT assays for detecting and quantifying immune responses.

CO4: Apply experimental skills in producing and purifying polyclonal antibodies for immunological studies.

List of Experiments

(Any 8 experiments can be done)

1. Agglutination Assay – Detect antigen-antibody interaction through visible clumping.
2. Latex Agglutination – Identify antigens or antibodies using latex bead clumping.
3. Ouchterlony Double Diffusion – Analyze antigen-antibody reaction in gel by precipitation lines.
4. Single Radial Immunodiffusion– Measure antigen concentration by radial diffusion in antibody gel.
5. Immunoelectrophoresis– Separate and detect proteins using electrophoresis and antibody reaction.
6. Rocket Immunoelectrophoresis– Quantify antigens by the height of precipitin rockets in gel.
7. Countercurrent Immunoelectrophoresis– Rapid detection of antigen-antibody reaction under electric field.
8. ELISA Technique– Detect and quantify antigens or antibodies using enzyme-linked antibodies.
9. Polyclonal Antibody Production– Generate antibodies in animals against specific antigens.
10. IgG Antibody Purification –Isolate Immunoglobulin G from serum using standard methods.
11. Antibody-Enzyme Conjugation – Link antibodies with enzymes for detection assays.
12. ELISPOT Assay – Detect cytokine-secreting cells at the single-cell level.

Text books:

1. Practical Immunology by Frank C. Hay & Olwyn M.R. Westwoo
2. Essential Immunology: A Textbook of Immunology" by Ivan M. Roitt and Peter J. Delves

Reference Books:

1. Kuby Immunology by Jenni Punt, Sharon Stranford, Patricia Jones, and Judith A. Owen
2. Roitt's Essential Immunology by Peter Delves et al.
3. Janeway's Immunobiology by Kenneth Murphy & Casey Weaver

Mapping of Course Outcomes with Program Outcomes (POs)

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

**3/2/1 indicates strength of correlation: 3 – High, 2 – Medium, 1 – Low*

6th SEMESTER

BIOINFORMATICS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT3102**

Prerequisites: Basic knowledge of biology, metabolic pathways, databases and computer programming.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Retrieve and use biological databases and various tools available for biological data mining.

CO2: Analyze a variety of omics data and carry out basic sequence alignments to understand protein functions in health and diseases.

CO3: Integrate information available on structure and function of proteins and pathways for the development of drugs and study their efficacy.

CO4: Apply biological databases, molecular visualization and modeling tools to predict the function of specific proteins or enzymes in the progression of human diseases.

Module I **(10 Hours)**

Introduction and Applications of Bioinformatics; Databases: Importance of databases; DNA, Protein sequence and structure databases (NCBI, EMBL, DDBJ, Uniprot, PDB, CSD, PIR, GENBANK, SWISSPROT, TrEMBL, SNP, CATH, SCOP, Pfam); Metabolic pathway databases (KEGG, MetaCyc); Specialized Genomic resources; Database retrieval tools and analysis packages

Module-II **(10 Hours)**

Sequence Alignment: Local, Global and Multiple sequence Alignment; Dynamic programming, Needleman-Wunsch algorithm, Smith-Waterman algorithm; PAM, BLOSUM matrices; Predictive Methods Using DNA And Protein Sequences (Algorithms to predict ORF, promoters, splice sites)

Module-III **(10 Hours)**

Molecular Modelling and Drug Designing: Protein secondary and tertiary structure prediction methods. *Ab initio* and Homology modeling; Molecular Mechanics and force fields; Molecular Dynamics simulations; Computer aided drug design (CADD); Molecular Docking, QSAR analysis (Molecular Descriptors, ADMET properties)

Text Books:

1. Bioinformatics: Sequence and Genome Analysis. By Mount DW. Spring Harbor Press, 2016
2. Introduction to Bioinformatics. By Arthur Lesk, Oxford University Press.,2008

Reference Books

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. By Baxevanis AS and Ouellette BF, Wiley International Science.
2. Bioinformatics computing. By Bryan Bergeron, Prentice Hall Inc

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

DOWNSTREAM PROCESS ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Core**	**Course Code:**	**BT3104**

Prerequisites: Undergraduate mathematics, and basic knowledge on biological processes

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Learn the fundaments of downstream processing

CO2: Evaluate the desired downstream process unit operation to separate the products

CO3: To illustrate the upstream and downstream processing for product recover and purification.

CO4: Apply the principle, working and application of major unit operations in Bioprocessing of industrially important products

Module-I: **(7 Hours)**

Basic concepts of Bio-separation Process: Importance of downstream processing in biotechnology, Characteristics of biological molecules, Characteristics of different bio-products, Physico-chemical basis of different bio-separation processes; Purification strategies and methodologies.

Module-II: **(8 Hours)**

Unit operation in Downstream processing: Filtration: Theory of filtration, Darcy's law, derivation, Filtration at constant pressure and at constant rate; empirical equations for batch and continuous. Centrifugation: Basic principles, design characteristics; ultracentrifuges: principles and applications. Membrane based bio-separation methods: Separation of intracellular, extra- cellular, heat and photosensitive materials, filtration membrane, cross flow system, micro- filtration, reverse osmosis, Ultra filtration.

Module-III: **(8 Hours)**

Downstream Processes: Cell disruption methods (mechanical, chemical and biological methods); precipitation of protein (solvent and salting out methods); solvent extraction of bioprocesses (liquid-liquid, aqueous two phase and super critical fluid extraction); adsorption and absorption process; Dialysis, Electrodialysis

Module-IV: **(7 Hours)**

Finishing of Biological products: Drying: Equilibrium mechanism, theory of drying, drying rate curve, batch and continuous drying; Crystallization: Factors governing nucleation and crystal growth, theory of crystallization. Batch and continuous crystallization

Text Books

1. Principle of Fermentation Technology. By P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth and Heinemann. Elsevier
2. Bioprocess Engineering Principles (Second Edition), By Pauline M Doran, Academic Press.
3. Introduction to Biochemical Engineering. By D.G. Rao, 2nd Edition, Tata McGraw-Hill Education.

Reference Books

1. Fundamentals of Biochemical Engineering. By Rajiv Dutta, Ane Books India, Springer.
2. Bioprocess Engineering Basic Concepts. By Michael L. Shuler and Fikret Kargi. Prentice Hall (2nd Edition)
3. Biochemical Engineering and Biotechnology. By GHASEM D. NAJAFPOUR, Elsevier.

Mapping of Course Outcomes with Program Outcomes (POs)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	1	1	-	-	-	-	-
CO2	3	3	1	-	-	1	1	-	-	-	-	-
CO3	3	3	1	-	-	1	1	-	-	-	-	-
CO4	3	3	1	-	-	1	1	-	-	-	-	-

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

FOOD PROCESS ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT3202**

Prerequisites: Fundamental knowledge in microbiology, Industrial microbiology and biochemistry.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Ability to understand the basics, operations and general aspects related to food processing and industry.

CO2: Understanding the various processing and preservation methods.

CO3: Understanding the function and application of enzymes in food processing and various food products

CO4: Ability to understand various scientific methods in Post-harvest technology and the relevance of food regulating authorities

Module- I (**08 hours**)

Introduction to food process engineering, General aspects of food industry, Analysis of food, major ingredients present in different food & food products, Food additives color, flavor, vitamins;; preliminary operations. Different Food processing methods: Blanching, pasteurization, sterilization, extrusion cooking, micro wave processing.

Module- II **(08 hours)**

Food Preservation; by Drying, Refrigeration. Food conversion operation: Size reduction- Solid foods and liquid foods. Methods for improved food processing: Enzymes in bakery, fat/oil industries, beverage production, sugar syrup.

Module-III **(08 hours)**

Production and utilization of food products - soft and alcoholic beverages, dairy products, meat, and fish products, treatment and disposal of food processing wastes for value added products. Nutraceuticals and Functional Foods. Microbial and Chemical safety of food products: heavy metal, fungal toxins, pesticide and herbicide contamination, Food preservatives.

Module-IV **(06 hours)**

Post-harvest technology for food preservation: canning, dehydration, ultrafiltration, sterilization, irradiation etc. Food standards and quality maintenance: FPO, PFA, Agmark, ISI, HACCP, FSSAI food plant sanitation and cleaning in place (CIP).

Text Books

1. Modern Food Microbiology. By J. M. Jay, M.J. Loessner, D.A. Golden. Springer
2. Food Microbiology. W. C. Frazier, D. C. Westhoff
3. Introduction to food engineering. R.P. Singh and D.R. Headman, Academic Press
4. Functional Foods and Biotechnology. K. Setty and D. Sarkar, CRC Press. McGraw Hill Publisher.

Reference Books

1. Frontiers in Food Biotechnology- C. Sharma, A. K. Sharma and K.R. Aneja, Nova Science Publishers
2. Food Hygiene, Microbiology and HACCP- S.J. Forsythe and P.R. Hayes, Springer (erstwhile Aspen Publlshers)

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

STEM CELL ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT3204**

Prerequisites: Basic knowledge on cell biology, physiology, material properties and mechanics.

Course Outcomes (COs):

CO1: Understand the properties, types, and regulatory mechanisms of various stem cells including embryonic and adult stem cells.

CO2: Demonstrate knowledge of techniques used in the identification, isolation, and differentiation of somatic stem cells, hematopoietic stem cells, & mesenchymal stem cells.

CO3: Apply genetic engineering and screening methods such as gene therapy, cell sorting, and stem cell-based drug discovery in practical and clinical scenarios.

CO4: Evaluate the therapeutic applications of stem cells in diseases like Parkinson's, diabetes, & burns**,** while understanding the ethical, social, and regulatory aspects of stem cell therapy.

Module I **(8hour)**

Properties of stem cells: pluripotency, totipotency, adult stem cells, umbilical cord stem cells. Embryonic stem cell: Germinal stem cells, General methods of characterization of stem cells, molecular mechanisms Cell cycle regulation in stem cells. Stem cell niches, Stem cell lineage tracing, cell signaling in stem cell. Embryonic stem (ES) cells: Isolation of ES cells, Salient features and application of ES cells. Maintenance of ES in undifferentiated state. In vitro fertilization, culturing of embryos-isolation of human embryonic stem cells, blastocyst, inner cell mass, growing ES cells in lab, laboratory tests to identify ES cells, stimulation ES cells for differentiation.

Module-II **(8hour)**

Adult stem cells: Somatic stem cells, test for identification of adult stem cells, adult stem cell differentiation, trans differentiation, plasticity, different types of adult stem cells. Hematopoietic Stem Cells (HSC): Identification and Characterization of HSCs, Sources of HSC , Clinical use of HSC. Mesenchymal and Neural Stem Cell: Embryonic origin of MSC's, Harvesting, Isolation and Characterization, Differentiation studies of MSC's, Neural stem cell and Neural crest stem cell.

Module III **(6 hour)**

Genetic engineering and Screening technique in stem cells: Gene therapy, genetically engineered stem cells. Screening stem cell techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging, stem cell based drug discovery, drug screening and toxicology.

Module-IV **(8 hour)**

Therapeutic application of stem cells Therapeutic applications in Parkinson disease, Neurological disorder, limb amputation, heart disease, spinal cord injuries, diabetes, burns, HLA typing, Alzheimer's disease, tissue engineering application. Stem cell regulations, debate, social and ethical concerns. Regulatory considerations and FDA requirements for stem cell therapy.

Text Books:

1. Stem Cell Engineering: Principles and Applications, Gerhard M. Artmann, Stephen Minger, Jürgen Hescheler,Springer-Verlag,2010.
2. Stem Cells: Scientific Progress and Future Research Directions by National Institutes of Health (NIH), 2013.
3. Tissue Engineering and Regenerative Medicine: A Nano Approach by Murugan Ramalingam, Pekka Vallittu, Ugo Ripamonti, Wan-Ju Li, Springer-Verlag, 2012.

Reference Books

1. Principles of Tissue Engineering (Fourth Edition) by Robert Lanza, Robert Langer, Joseph P. Vacanti
2. Stem Cell Engineering: Methods and Protocols edited by Peter W. Zandstra and Keisuke Kaji
3. Stem Cells: Methods and Protocols edited by Ian Wilmut and Miles D. Wilkinson

Mapping of Course Outcomes with Program Outcomes (POs)

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

**3/2/1 indicates strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMATERIALS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT3206**

Prerequisites: Fundamentals of stem cell engineering, growth factors, and cell metabolism.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand the importance of biomaterial interactions with cells, tissues, and the host body

CO2: Analyze properties of biomaterials, demonstrate the concepts of cell-scaffold interactions, growth factor signaling, and the role of biomaterials in tissue development

CO3: Apply engineering principles to design and optimize biomaterials for specific applications

CO4: Fabricate biomedical implants and tissue-engineered products for modern approaches to surgery and prosthetics

Module I **(10 Hours)**

Introduction to biomaterials, Concept of biocompatibility. Structural properties (mechanical, thermal, optical, electrical and surface properties) of biomaterials, Characterization of Materials: Mechanical properties: Stress-Strain Behavior, Mechanical Failure: Static & Dynamic Failure, Friction & wear failure, Visco-Elastic material behavior. Assessment of biocompatibility of biomaterials.

Module-II **(10 Hours)**

Properties of Biomaterials: Electrical Properties & Piezoelectricity, Optical Properties, X-ray Absorption, Acoustic Properties, Density & Porosity Diffusion Properties. Metallic Biomaterials: Introduction & Implants materials, metallic implants, stainless steels, CoCr Alloys, Ti Alloys, hydroxyapatite glass, Corrosion of metallic Implants. Hydrogels, self-assembling peptides, 2D and 3D matrices (scaffolds) of biomaterials for tissue engineering, Soft tissue and hard tissue replacement, cardiovascular implants, Biomaterials for ophthalmology, orthopaedic and dental implants.

Module-III **(10 Hours)**

Ceramic Biomaterials- Introduction, Non-absorbable materials like Alumina, Carbons & Zirconia, Biodegradable Ceramics like Calcium phosphate, Aluminum-Calcium-Phosphate (ALCAP) Ceramics. Bioactive ceramics like Glass ceramics. Polymeric Biomaterials-Introduction, Polymerization & Basic structure, physicochemical properties of polymers, Polymers used as Biomaterials: Polyvinylchloride (PVC), Polyethylene (PE), Plolymethylmetacrylate (PMMA). Polymers for drug delivery. Composite Biomaterials-Structure, Bounds & Properties, Anisotropy of Composites, Particulate Composites, Fibrous Composites & Porous Materials. Design concept of developing new materials for bio-implant applications

Text Books:

1. Biomaterials –An Introduction, 3 Ed– Joon Park & R.S.Lakes-Springer
2. Biomaterials- Joyce Y.Wong & Joseph D. Bronzino – CRC Press

Reference Books

1. Buddy D. Ratner Allan S. Hoffman Frederick J. Schoen Jack E. Lemons. Biomaterials Science, Second Edition: Wiley Science2004.
2. Biomaterial. By Bhatt SV, Narosa publishing house

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

NANOBIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT3208**

Prerequisites: Basics of organic chemistry, Physics, Biology and Molecular biology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Articulate the fundamental principles of nanobiotechnology, including nanoscale properties, and cell-nanostructure interactions.

CO2: Demonstrate understanding of nanoscale characterization tools and fabrication methods used in creating and analyzing Nano biomaterials.

CO3: Analyze the structural and functional aspects of nanobiomaterials and their synthesis via chemical and biological approaches.

CO4: Learn and analyze the operational principles of MEMs and nanobiosensors and evaluate applications of nanobiotechnology in medicine, diagnostics, considering biosafety.

Module-I: (Fundamental Concepts and its Potential) (7 Hours)

Introduction: History of nanotechnology, Definition of nanotechnology, small-strange and useful, Fundamental sciences of Nanobiotechnology: Particle size, surface tension and relation to size, Changes in properties: size, shape, density, melting point, wet ability. Nano-biomimicry, Biological building blocks. Cell-nano structure interaction.

Module-II: (Visualization and Principles of Nanobiotechnology) (8 Hours)

Structural principles of nanobiotechnology (self-assembly and self Organisation), Functional principles (Energetics, Chemical Transformation etc). Nanostructure visualization techniques: Electron microscopy, Scanning probe Microscopy (AFM, STM). Carbon based nanomaterials- fullerenes, graphene, nanotubes, Quantum dots, Metal-based nanoparticles. Protein-based & DNA- based Nanostructures. Magnetosomes.

Module-III: (Strategies of fabrication and Synthesis of Nanoparticles) (8 Hours)

Micro-fabrication- Approaches & methods (photolithography, etching). Soft lithography, Synthesis of Nanomaterials: Sol-Gel synthesis; Micro-emulsions synthesis. Biological nanoparticles synthesis: Plant and microbial mediated synthesis. Micro-machines: MEMS; BioMEMS, microarray, Lab-on-a-chip devices and their potential in nanobiotechnology.

Module-IV (Nanoanalysis and Applications) (7 Hours)

Nanoanalysis and nanobiosensors- Different classes, molecular recognition elements, transducing elements. Application of various transducing elements as part of nanobiosensors. Medical Applications of Nanobiotechnology- Polymeric & metal nano-particles for drug delivery, Nano-technology in Cancer Diagnosis, Nanotoxicity: Nanoparticles' Cytotoxicity. Nanotechnology safety and the environment.

Text Books:

1. Bionanotechnology by David S. Goodsell, 2004, Wiley Publications.
2. Textbook of Nanoscience and Nanotechnology by B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday, 2012. Springer Berlin

Reference Books

4. Concepts, Applications and Perspectives, Vol I, CM Niemeyer and CA Mirkin, Wiley VCH.
5. Nanobiotechnology: Concepts, Applications and Perspectives, Vol II, CM Niemeyer and CA Mirkin, Wiley VCH.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BUSINESS MANGEMENT (3-0-0)

Program	Stream	Sem.	Subject Name	Subject Code	Credit	L	T	P	Contact Hours
UG	B.Tech	$5^{th}/6^{th}$ Sem	Business Management	BH-3401	3	3	0	0	30

Course Outcomes:

v. Comparing and contrasting efficient functional models of business management by integrating the three core areas such as Finance, Human Resource and Marketing Management.

vi. Executing the Management principles in all the functional areas of business.

vii. Correlating the interrelations and interdependence of the areas of Management in a business organisation.

viii. Assessing the functional and managerial practices in business organisations.

MODULE-1: Management Principles - 8 hours

Management Concepts, Nature and Functions, Management Process and Roles of Managers, Levels of Management and Managerial Skills, Theories of Management – Contributions of F.W.Taylor, Henry Fayol, Elton Mayo, Line and Staff Relationship, Centralisation and Decentralisation, Delegation of Authority , Management thoughts in Modern Trend –Systems Approach

MODULE-2: Financial Management – 8 hours

Concept, Financial function and Role of Financial Managers, Instruments of raising short-term and long-term funds, Capital Structure, Techniques of Project Appraisal, Components of Working Capital, Operating Cycle, Factors affecting requirement of Working Capital.

MODULE-3: Human Resource Management - 7 hours

Nature and Scope of Human Resource Management, Manpower Planning, Recruitment and Selection Methods, Performance Appraisal, Need, Objectives, Modern methods of Appraisals: 720 degree, MBO, Assessment Centre Method, Talent Acquisition, Training Need Analysis, Career Planning, Organisational Citizenship Behaviour.

MODULE- 4: Marketing Management - 7 hours

Concept, Nature, Scope and Importance, Marketing Mix and 7P’s of Marketing, Segmentation, Targeting, Positioning, Factors influencing consumer decision-making, e-marketing and Green Marketing

Reference Books:

8- *Modern Business Organisation and Management*, S.A. Sherlekar, Himalaya Publishing House, 2016.
9- *Essentials of Management*, Stephen P. Robbins, 6th Edition, Pearson, 2010.
10- *Financial Management*, Sheeba Kapil, 1st Edition,Pearson, 2013.
11- *Human Resource Management Text and Cases*, K. Aswathappa, 10th Edition,TMH, 2023
12- *Marketing Management*, Rajan Saxena, 6th Edition, TMH publishing house, 2022.
13- *Principles of Management*, Dipak Kumar Bhattacharyya, 1st Edition, Pearson, 2011
14- *Mgmt (Principles of Management)*, Willium& Tripathy, 1st Edition, Cengage Learning, 2016

CO-PO Mapping

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

ENTREPRENEURSHIP DEVELOPMENT (3-0-0)

Program	Stream	Sem.	Subject Name	Subject Code	Credit	L	T	P	Contact Hours
UG	B.Tech	5th/6thSem	Entrepreneurship Development	BH-3403	2	3	0	0	30

Course Outcomes:

5. Exemplifying the business opportunities, social responsibilities and the support system for setting up an enterprise.
6. Determining stages of Entrepreneurial Process starting from idea generation, developing a business plan and operational aspects of an Enterprise.
7. Appraising the different funding options and Financial Management of an enterprise.
8. Assessing the Start-up management practices like incubation, mentorship and Government initiatives.

MODULE-1: Introduction to Entrepreneurship - 8 hours

Concept, Functions of an Entrepreneur, Entrepreneurial Process, Entrepreneurial Motivation and Barriers, Traits to be a successful Entrepreneur, Creativity and scope of Entrepreneurship in India: Types of new age business (FinTech, EdTech, Healthcare, Agripreneurship, Defence, Drone, Space, IT, Robotics, Digital Transformation, Women-Entrepreneurship, Social Entrepreneurship, Corporate Social Responsibility, Business Ethics – Role of Values in Management.

MODULE-2: Entrepreneurial Idea into Action - 8 hours

Developing a Business Idea; Opportunity, Methods and Creativity, Deciding to set up a start-up, Forms of business organisations (Sole tradership/propreitorship, Partnership, Joint-Stock Company) and MSMEs (Micro, Small and Medium enterprises), Size and Location of the enterprise, Feasibility Study: Market Survey, Techno-economic feasibility and preparing a Project Report.

MODULE-3: Entrepreneurial Finance and Funding - 7 hours

Sources of funding(Bootstrapping, Angel Investors, Venture Capital, Crowdfunding etc.) Project Investment Analysis, Break-Even Analysis, ROI Analysis, Basics of Income Statement and Balance Sheet.

MODULE- 4: Managing an Enterprise – 7 hours

The Start-up ecosystem, Business Incubators, Start-up Accelerators, Mentorship and Networking, Failure and Resilience, Risk Management, Ethical dilemmas and Exit Strategies, Start-up Policy and Initiatives of the Government.

Reference Books:

7. *Entrepreneurship: Successfully Launching New Ventures*, B.R. Barringer, 6th, Pearson, 2020
8. *Fundamentals of Entrepreneurship and Project planning*, Madhurima Lall, 1st, Sultan Chand & Sons, 2021
9. *Entrepreneurial Development,*S.S. Khanka, 1st Edition, S Chand and Company, 1999
10. *Entrepreneurship Development and Small business enterprises,* P.M. Charantimath, 3rd Edition, Pearson, 2019
11. *Entrepreneurship: Theory, Process and Practice*, Donald F Kuratco, 11th, Cengage, 2023
12. *Entrepreneurship*, Robert. D. Hisrich & Sabyasachi Sinha, 11th Edition, TMH, 2020

CO-PO Mapping

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

ENVIRONMENTAL ENGINEERING - Subject Code IP 3401					
CREDIT	2		L-3	T-0	P-0
PREREQUISITES: Basic Physics, Basic Chemistry					
COURSE OUTCOMES At the end of the course a student will be able to					
CO1	Understand the multidisciplinary nature of environmental science and ecosystem structure and functions				
CO2	Analyze various forms of environmental pollution and assess their impact using scientific parameters				
CO3	Demonstrate knowledge of water and wastewater treatment processes and air pollution control technologies				
CO4	Evaluate the role of environmental policies, EIA, and sustainable practices in pollution control and resource conservation				
CONTENT					
Module 1 (10 hours)	**Fundamentals of Environment and Ecosystem:** Multidisciplinary nature of environmental Engineering. **Study of Ecosystem:** Definition, Properties, Structure and Function of an ecosystem. Food chains, food webs, Flow of Energy, Ecological Pyramids, Biogeochemical cycles, Types of ecosystems, Bioaccumulation, Bio magnification, ecosystem value, Degradation of Ecosystem. **Concept of Environment and pollution:** Atmospheric chemistry, soil chemistry, water quality characteristics, DO, BOD and COD, water pollution, Marine Pollution, soil pollution, thermal pollution, nuclear hazard, Air Pollution: Air Quality, cause and effects of air pollution, Water and air quality standards, and Index, Noisepollution: Introduction, Noise standards, measurement, Ln Concept and control				
Module 2 (8 hours)	**Water treatment process**: Pre-treatment of water, conventional process, advanced water treatment process. **Waste water treatment process**: Natural Treatment, Engineering Treatment -Pre-treatment, primary and secondary waste water treatment process **Air Pollution Control**: The natural self-cleansing properties of Environment, Air pollution meteorology, Atmospheric dispersion, Diffusion equation, ground level emission, plume rise, Effective stack height, Air Pollution control from stationarysources by installing Engineering devices, Flue gas desulphurisation, NOX removal.				
Module 3 (8 hours)	**Solid waste management:** Source, classification, separation, storage and transportation of solid wastes, Waste minimization techniques, Benefits of waste minimization, reuse, recycle, thermal and biological treatment, secure land fill technique. **Impact of Environmental pollution and related issues:** Global climate change,				

	global warming and greenhouse gases, Acid rain, ozone layer depletion, healthissues.
Module4 (4 hours)	**Environmental Impact Assessment:** EIA procedure, Preparation of an EIS From unsustainable to sustainable development, circular economy, Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Preventionand Control of Pollution) Act, Wildlife Protection Act.
TEXTBOOKS	
1.	Fundamentals of Ecology, M.C.Dash, Tata McGraw Hill, 2006.
2.	Environmental Pollution Control Engineering, C.S. Rao, New Age International Publishers, 2018
3.	Environmental Engineering, G. Kiely, TMH, 2007
REFERENCES	
1.	Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous, McGraw Hill.
2.	Introduction to Environmental Engineering and Science, G.M. Masters, Pearson, 2015
3.	Integrated Solid Waste Management, G. Tchobanoglous, McGraw Hill, 2014
4.	Water Supply Engineering, S.K. Garg; Khanna Publishers, 37th Edition

CO-PO-PSO MAPPING

COs	**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	3	2	1	1	1	2	3	1	1	2	1	2	2	2
CO2	3	3	2	2	2	2	3	1	1	2	1	2	2	2
CO3	3	3	3	2	2	2	3	1	2	2	2	3	3	3
CO4	2	2	2	2	1	3	3	2	2	2	2	3	3	3

Correlation Level 1: Slight 2: Moderate 3: High

INDUSTRIAL SAFETY ENGINEERING- Subject Code: IP3403					
CREDIT	3		L-3	T-0	P-0
PREREQUISITES: NA					
COURSE OUTCOMES At the end of the course a student will be able to					
CO1	Apply safety principles in various work environments, especially in construction and machine operations.				
CO2	Identify safety hazards, implement safety measures,				
CO3	Analyse risks to prevent accidents and injuries.				
CO4	Understand of safety protocols, policies, and the responsibilities of individuals and organizations in ensuring a safe working environment.				
CONTENT					
Module 1 (6 hours)	**Safety Introduction:** Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.				
Module 2 (7 hours)	**Personal Protection in work environment:**Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.				
Module 3 (7 hours)	**Safety issues in Construction:** Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.				
Module4 (12 hours)	**SafetyHazardsinMachines and Hazardidentificationandanalysis:** Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices.Safetyinturning,andgrinding.WeldingandCutting-SafetyPrecautionsofGas welding and Arc Welding. Material Handling-Classification-safety consideration-manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance.				

	Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identificationofhazards:Inventoryanalysis,Fireandexplosionhazardratingofprocessplants The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operabilitystudy(HAZOP))–methodology,criticalityanalysis,correctiveactionandfollow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).
TEXTBOOKS	
1.	R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2.	Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
3.	Krishnan, N.V. (1997).Safety management in Industry. Jaico Publishing House, New Delhi.
REFERENCES	
1.	John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.
2.	Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.
3.	Alan Waring. (1996). Safety management system. Chapman & Hall, England.
4.	Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai

CO-PO-PSO MAPPING

COs	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	3	3	3	2	2	2		3					3	2
CO2	3	3	3	2				3	2				3	2
CO3	3	3	3	2				3					3	2
CO4	2	2	1	2		3		3	2	2			2	2

Correlation Level 1: Slight 2: Moderate 3: High

DOWNSTREAM PROCESS ENGINEERING LAB			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Professional Core**	**Course Code:**	**BT3502**

Prerequisites: Undergraduate mathematics, and basic knowledge on biological processes

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Understand the fundamentals of recovery.

CO2: Perform purification operations forbiopharamaceutical production.

CO3: perform various chromatographic techniques.

CO4: Precipitate proteins using salting out process.

List of Experiments

(Any 8 experiments can be done)

1. Harvesting of cells using filtration, centrifugation
2. Cell disruption techniques.
3. Precipitation of protein.
4. Dialysis Techniques
5. Column chromatography
6. Protein separation by chromatography e.g. Gel chromatography
7. Membrane filtration
8. Membrane based separation
9. Extraction techniques (like liquid-liquid and Aqueous two-phase extraction)
10. Drying

Text Books

1. Practical Biotechnology: Principles and Protocolsby H. N. Thatoi, Supriya Dash, and Swagat Kumar Das
2. Satinder Ahuja, “Handbook of Bioseparations”, Vol 2, Academic Press, 1st Ed., 2000.

Reference Books

1. Downstream Processing of Proteins: Methods and Protocols”, Humana Press,2000

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

Bioinformatics Lab			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Professional Core**	**Course Code:**	**BT3504**

Prerequisites: Basic knowledge of biology, metabolic pathways, databases and computer programming.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Gain knowledge on biological databases and apply web-based tools for biological data mining.

CO2: Analyze a variety of omics data and carry out basic sequence alignments and phylogenetic tree analysis and predict secondary structure of proteins.

CO3: Integrate information available on structure and function of proteins and pathways for the development of drugs and study protein-ligand interaction using molecular docking.

CO4: Apply molecular visualization and molecular modeling tools to predictthe function of specific proteins through molecular dynamic simulations.

List of Experiments

(Any 8 experiments can be done)

1. Retrieving Human genome data, OMIM, SNP databases to understand genetic and metabolic disorders.
2. Mining genomic data to identify genomic features: codon usage, repeats, Homologous sequences etc.
3. Making Phylogenetic tree of given sequences by using ClustalW and PHYLIP.
4. Gene and promoter prediction for Prokaryotes and eukaryotes (comparative analysis by using different tools.
5. Learning about molecule visualisation software like Rasmol, Pymoletc.
6. Primary Structural databases: pdb, ndb, csd and Derived databases of structures: DSSP, FSSP, CATH &SCOP.
7. Prediction of secondary structures of proteins.
8. Prediction of Tertiary structure of proteins and Validation of model protein structure: Energy minimization, Procheck, verify 3D, Prosa II, ERRAT etc.
9. Molecule drawing. Conversion of 2D structure to 3Dstructure.
10. Molecular docking and analysis of receptor withligand
11. Molecular Dynamics simulation

Text Books:

1. Bioinformatics: Sequence and Genome Analysis. By Mount DW. Spring Harbor Press
2. Introduction to Bioinformatics. By Arthur Lesk, Oxford University Press.

Reference Books

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. By Baxevanis AS and Ouellette BF, Wiley International Science.
2. Bioinformatics computing. By Bryan Bergeron, Prentice Hall Inc

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

7th SEMESTER

INTRODUCTION TO SYSTEMS BIOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT 4201**

Prerequisites: Basic knowledge of Biochemistry, Molecular Biology and Genetic Engineering, and any high-level programming language (preferably MATLAB).

Course Outcomes (COs):

On successful completion of this course, the students should be able to:

CO1: Construct and analyze computational models of biological systems and phenomena.

CO2: Understand common mathematical and computational approaches to study biological problems.

CO3: Analyze specific case-studies on computational modeling and analysis of biological processes or systems.

CO4: Apply numerical and computational methods to explore the behavior of biological systems under normal and disease conditions.

Module I **(6 hour)**

Introduction to key concepts of systems biology: Dynamical systems, networks, self-organization, emergent properties, homeostasis, robustness.

Module II **(8 hour)**

Analysis of dynamical systems: Basic concepts of modeling biological systems using ordinary differential equations; Numerical methods of solving ordinary differential equations- Euler method; Analysis of dynamical systems: Basic concepts of modeling biological systems using ordinary differential equations; methods of solving ordinary differential equations describing biological processes. Graphical analysis of ordinary differential equation based models - direction field, phase plane; stability analysis of linear and non-liner systems of ordinary differential equations; Concept of Bifurcation.

Module III **(8 hour)**

Modeling molecular network: Concept of molecular network and network motifs; Mathematical formulations for elementary molecular processes - Law of Mass Action, ligand binding, enzymatic reaction, transcription, translation; Analysis of biochemical switches, positive feedback, negative feedback, transcriptional circuits; Bifurcation, and hysteresis in network motifs.

Module IV **(8 hour)**

Analysis of large networks: Basic concepts of Graph theory - degree distribution, clustering coefficient, path length, shortest path, Betweenness centrality; Random Networks - Erdös-Rényi Model. Properties of scale free networks; Barabási-Albert (BA) model; Network by duplication and divergence; Properties of large protein-protein interaction network, gene regulatory network, and metabolic network.

Text books:

1. Ingalls, Brian P. Mathematical Modeling in Systems Biology: An Introduction (1st edition). MIT Press, 2013.
2. Wilkinson, Darren J. Stochastic Modelling for Systems Biology. Chapman & Hall, 2006.
3. Junker, Bjorn H.; Schreiber, Falk (ed). Analysis of Biological Networks. John Wiley & Sons, 2008.

Reference Books:

1. Alon, Uri. An Introduction to Systems Biology-Design Principles of Biological Circuits.
   CRC Press, 2007.
2. Szallasi, Zoltan; Stelling, Jörg; Periwal, Vipul (ed). System Modeling in Cell Biology, From Concepts to Nuts and Bolts. The MIT Press, 2006.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

METABOLIC ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT4203**

Prerequisites: Fundamentals of Biochemistry, Cellular Metabolism and Genetic Engineering,matrix algebra, and computer programming.

Course Outcomes (COs):

On successful completion of this course, the students should be able to:

CO1: Construct and analyze computational models of biological systems and phenomena.

CO2: Understand common mathematical and computational approaches to study biological problems.

CO3: Analyze specific case-studies on computational modeling and analysis of biological processes or systems.

CO4: Apply numerical and computational methods to explore the behavior of biological systems under normal and disease conditions.

Module I **(8 hour)**

Basic concepts of metabolic engineering; Demonstrates metabolic engineering in action with numerous examples of pathway engineering for strain improvement, product overproduction, byproduct minimization, extension of substrate utilization range Regulation of Metabolic Pathways; Basic biochemical pathways, primary and secondary metabolism, Regulation of Metabolic Pathways, Enzyme regulation, rate limiting steps.

Module II **(8 hour)**

Metabolic flux analysis (MFA); Models of cellular reactions, stoichiometry of cellular reactions, reaction rates, dynamic mass balances, metabolic network, MFA of exactly determined systems, over determined systems, Parameter estimation.

Module III **(8 hour)**

Constraint based metabolic flux analysis; Underdetermined systems, concept of linear programming to metabolic model, implementation of these concept to genomic scale metabolic model, Flux balance analysis (FBA), Regulatory on-off Minimization (ROOM) and Minimization of metabolic adjustments (MOMA), Elementary mode analysis, Extreme pathways.

Module IV **(8 hour)**

Metabolic Fluxes by radiolabeled tracer; Determination of metabolic fluxes by isotope labeling, 13C labeling metabolic flux analysis using analytical techniques, stationary and in-stationary assumption, Metabolic Control Analysis (MCA) - control coefficients, MCA of linear and branched pathways, control of flux distribution at branch point, MCA case study.

Text books:

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998.
2. Jens Nielsen (eds.), Metabolic Engineering, Advances in Biochemical Engineering/ Biotechnology, springer, 2008.

Reference Books:

1. Bernhard Palsson, Systems Biology: Constraint-based Reconstruction and Analysis, Cambridge University Press, 2015.
2. Y. Lee and E. T. Papoutsakis, Metabolic Engineering, Marcel Dekker, New York, 1999.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

MARINE BIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT4205**

Pre requisites: Knowledge on basic biology, ecology, marine flora and fauna

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Understand the structure and dynamics of marine ecosystems and Identify and classify major marine organisms, including microbes

CO2: Apply molecular tools for studying marine biodiversity and gene functions, and utilize systems biology techniques for analyzing marine omics.

CO3: Analyze marine organisms with commercial biotechnological potential

CO4: Evaluate ethical and regulatory frameworks in marine biotech research

Module I **(8 Hrs)**

Introduction to Marine Environment & Biological Diversity:The structure and dynamics of marine ecosystems,Identify and classify major marine organisms, including microbes,Marine biodiversity: taxonomy and distribution of marine flora and fauna, Marine microbial ecology and microbial interactions.

Module II **(8 Hrs)**

Marine genomics and metagenomics, Proteomics and transcriptomics in marine species ,Introduction to marine bioinformatics and databases, Applications of molecular tools in species identification and conservation and gene function prediction.

Module III **(8 Hrs)**

Marine Bioproducts:Identification of marine organisms with commercial biotechnological potential, Bioactive compounds from marine organisms: pharmaceuticals, enzymes, pigmentsBiotechnological applications of marine extremophiles, Marine natural products: isolation, purification, characterization

Module IV **(8 Hrs)**

Environmental Marine Biotechnology:Bioremediation of marine pollutants (oil spills, plastics, heavy metals), Biosensors for marine environmental monitoring, Climate change impact on marine ecosystems.

Text Books:

1. Recent Advances in Marine Biotechnology Vol. II" by M Fingerman and R Nagabhushanam Mary
2. Marine Biotechnology by Shubha Agarwal Govil, ,Himalaya Publishing House; First Ed
3. Essentials of marine biotechnology, by Se-Kwon Kim Springer Nature Switzerland; 1st ed.

Reference Books:

1. Marine Biotechnology II (Advances in Biochemical Engineering/Biotechnology)" by Yves Le Gal and Roland Ulber

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

INTRODUCTION TO DRUG DESIGN AND DISCOVERY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Professional Elective**	**Course Code:**	**BT4207**

Prerequisites: Fundamentals of Biochemistry, Cellular Metabolism and Genetic Engineering, matrix algebra, and computer programming.

Course Outcomes (COs):

On successful completion of this course, the students should be able to:

CO1: Understand the drug development process and use it for drug development and discovery.
CO2: Use experimental approaches to drug design and discovery.
CO3: Analyze specific case studies on computational approaches to drug discovery.
CO4: Apply computer-aided drug discovery and delivery methods with existing case studies.

Module I **(8 hour)**

Introduction to the drug discovery; Targets identification, Drug discovery: Drug scaffolds, Drugs derived from natural products, Existing drugs as a source for new drug discovery.

Module II **(8 hour)**

Structure and ligand based drug design uing computational method; Lead optimization; Stereochemistry in drug design and concept of Pharmacophore. Enzymes as targets of drug design : Enzyme kinetics, inhibition, rational design of enzyme Inhibitors.

Module III **(8 hour)**

Receptors as targets of drug design; In vitro ADME and In vivo Pharmacokinetics; Animal Models and Clinical trials; Intellectual property, Role of regulatory bodies.

Module IV **(8 hour)**

Introduction to computational drug delivery, Case studies related to drug development (Anticancer, antiparasitic 75 and antibiotics etc).

Textbooks:

1. Textbook of Drug Design and Discovery, Povl Krogsgaard-Larsen, Tommy Liljefors and, 3rd Ed., Taylor & Francis 2005
2. Drugs: From Discovery to Approval. Rick Ng 3rd Ed., John Wiley and Sons 2015

Reference Books:

1. Basic Principles of Drug Discovery and Development. Benjamin E Blass, 1st Ed., Acad Press 2015
2. 2.Textbook of Drug Design and Discovery, Edited by Kristian Stromgaard, Povl Krogsgaard-Larsen, Ulf Madsen. 4th Ed., CRC Press 2015

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

Sub Code: CS4101 Sub: Advanced AI (L-T-P:Credits) (3-0-0:3)

Prerequisites	Artificial Intelligence

Course Outcomes:

CO1 Understand and differentiate between various probabilistic graphical models including Bayesian Networks, Markov Networks, and their structural

CO2 Apply exact and approximate inference techniques such as variable elimination, belief propagation, and sampling methods for reasoning under uncertainty.

CO3 Develop and evaluate learning algorithms for graphical models, including parameter estimation, structure learning, and handling partially observed data.

CO4 Analyze advanced concepts in graphical models such as EM algorithm, hidden variables, causal inference, and decision-theoretic reasoning using utility and value of information.

Detailed Syllabus

Module-I **(7 Hours)**

Overview of Probability Theory, Bayes Networks, Independence, I-Maps, Undirected Graphical Models, Bayes Networks and Markov Networks, Local Models, Template Based Representations,

Module-II **(8 Hours)**

Exact Inference: Variable Elimination;Clique Trees, Belief Propagation, Tree Construction, Intro to Optimization, Approximate Inference: Sampling, Markov Chains, MAP Inference, Inference in Temporal Models

Module-III **(8 Hours)**

Learning Graphical Models : Introduction, Parameter Estimation, Bayesian Networks and Shared Parameters, Structure Learning, Structure Search, Partially Observed Data, Gradient Descent

Module-IV **(7 Hours)**

EM, Hidden Variables, Undirected Models, Undirected Structure Learning, Causality, Utility Functions, Decision Problems, Expected Utility, Value of Information

Text Books:

1. "Probabilistic Graphical Models: Principles and Techniques", Daphne Koller and Nir Friedman,MIT Press
2. "Pattern Recognition and Machine Learning", Christopher M. Bishop,Springer

References Books:

1. "Bayesian Reasoning and Machine Learning", David Barber, Cambridge University Press
2. "Machine Learning: A Probabilistic Perspective" Kevin P. Murphy, MIT Press

CO-PO Mapping:

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

(1:Low, 2:Medium, 3:High)

COURSE STRUCTURE FOR HONOURS

Sl. No.	Semester	Course Code	Subject (Theory)	Contact Hrs L-T-P	Credit
1	**5th**	BT3171	Basics of Animal Physiology	3-0-0	3
2	**6th**	BT3172	Biomaterials and Tissue Engineering	3-0-0	3
3	**7th**	BT4171	Genomics, Proteomics & Metabolomics	3-0-0	3
4	**7th**	BT4173	Drug Delivery System	3-0-0	3
5	**8th**	BT4172	Industrial Biotechnology	3-0-0	3
Subject (Sessional)					
6	**6th**	BT3572	Biomaterials and Tissue Engineering Lab	0-0-3	1.5
7	**7th**	BT4571	Biomolecular Modeling & Simulation Lab	0-0-3	1.5

Syllabus

BASICS OF ANIMAL PHYSIOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Honors**	**Course Code:**	**BT3171**

Prerequisites: Basic knowledge of biology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand the basic physiology of the human body.

CO2: Analyze the concepts and engineering principles that can be applied from the basic anatomy and physiology of human body.

CO3: Implement the knowledge of the human body functions during health and diseased conditions in day-to-day life to design new diagnostic tools.

CO4: Apply the principles of engineering, mathematics and physics to obtain a quantitative understanding of cellular, tissue and organ function in health and disease.

Module I **(6 Hours)**

Introduction to Anatomy and Physiology, Organization of the living system, Homeostasis and System Integration, Positive Feedback Loop in Homeostasis, Chemical Basis of Organization of the body.

Module-II **(8 Hours)**

Classification of bones, joints, Bones of limbs and major muscles of limbs and their actions, Skeletal muscle, Structure, Mechanism of muscle contraction, types of contraction, smooth muscle classification,Structure & function of Heart & blood vessels, Special functional tissue of heart, E. C. G., Cardiac cycle, Blood – composition, function, blood group, blood clotting, blood pressure regulation, Structure and Function of respiratory membrane, Pulmonary circulation, Mechanics of breathing, Transport and control of gases, Lungs volume and capacities.

Module-III **(8 Hours)**

Brain and spinal cord, peripheral autonomic nervous system, nerve physiology, Stretch Reflex Phenomena, Structure and Circuit of Neurons, Excitability of neuron, Neural Action Potential, Brain disorders, and Memory.

Module-IV **(8 hours)**

Endocrine Glands: types, location, description, and functions, Parts of the digestive system, Gastrointestinal tract and associated glands, Parts and functions of the urinary system, Kidney and the Immune System.

Text Books:

1. Guyton and Hall, Text Book of Medical Physiology, 2ND ed., 2004
2. Ganong'S Rev of Med Physiology, McGraw Hill, 2016.
3. Fundamentals of Anatomy & Physiology, 11th edition, Global edition, by Martini, Nath, and Bartholomew, Pearson, 2018.

Reference Books

1. K. Saladin, Anatomy & Physiology: The Unity of Form and Function, McGraw-Hill College, 7th edition,2014.
2. R. Drake, A. W. Vogl, Adam W. M. Mitchell, and R. Tibbitts, Gray's Atlas of Anatomy, Churchill Livingston, 2nd edition, 2014.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMATERIALS AND TISSUE ENGINEERING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Honors**	**Course Code:**	**BT3172**

Prerequisites: Fundamentals of biomaterials and physiology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Gain knowledge of biomaterial interactions with cells, tissues, and the host body

CO2: Understand the concepts of cell-scaffold interactions, growth factor signaling, and the role of biomaterials in tissue development.

CO3: Apply engineering principles to design and optimize biomaterials for specific applications.

CO4: Fabricate biomedical implants and tissue-engineered products for modern approaches to surgery and prosthetics.

Module I **(8 Hours)**

Introduction to biomaterials and Concept of biocompatibility; Structural properties (mechanical, thermal, optical, electrical and surface properties) of biomaterials; Properties of Biomaterials: Electrical Properties & Piezoelectricity, Optical Properties, X-ray Absorption, Acoustic Properties, Density & Porosity Diffusion Properties. Characterization of Mechanical properties: Stress-Strain Behavior, Mechanical Failure: Static & Dynamic Failure, Friction & wear failure, Visco-Elastic material behaviour; Assessment of biocompatibility of biomaterials.

Module-II **(8 Hours)**

Metallic Biomaterials: Introduction & Implants materials, metallic implants, stainless steels, CoCr Alloys, Ti Alloys, hydroxyapatite glass, Corrosion of metallic Implants. Hydrogels, self-assembling peptides, 2D and 3D matrices (scaffolds) of biomaterials for tissue engineering, Soft tissue and hard tissue replacement, cardiovascular implants, Biomaterials for ophthalmology, orthopaedic and dental implants.

Module-III **(8 Hours)**

Ceramic Biomaterials: Introduction, Non-absorbable materials like Alumina, Carbons & Zirconia, Biodegradable Ceramics like Calcium phosphate, Aluminum-Calcium-Phosphate (ALCAP) Ceramics. Bioactive ceramics like Glass ceramics, Polymeric Biomaterials-Introduction, Polymerization & Basic structure, physicochemical properties of polymers, Polymers used as Biomaterials: Polyvinylchloride (PVC), Polyethylene (PE), Plolymethylmetacrylate (PMMA). Polymers for drug delivery.Composite Biomaterials-Structure, Bounds & Properties, Anisotropy of Composites, Particulate Composites,

Fibrous Composites & Porous Materials. Design concept of developing new materials for bio-implant applications

Module-IV **(8 Hours)**

Elements for tissue engineering: cells, matrices, and biochemical/physical factors. Stem cells and differentiation. Biomaterials used and aspects related to the three-dimensionality of substrates. Chemical and mechanical stimuli. Scaffold: Concept and functions, Scaffold Properties-physico-chemical-mechanical and biological; Scaffold: Scaffold Design and Fabrication- conventional and advanced techniques for 2D and 3D design, Scaffold Characterization techniques, Cell- scaffold integration: Introduction, cell seeding techniques, Cell-scaffold interaction- cell adhesion, cell proliferation, cell migration and cell agglomeration, Assessment of tissue construct, Ethical and regulatory issues.

Text Books:

1. Biomaterials - An Introduction, 3 Ed.Joon Park &R.S.Lakes-Springer
2. Biomaterials- Joyce Y.Wong& Joseph D. Bronzino – CRC Press
3. G. Vunjak-Novakovic, R. Ian Freshney, Culture of Cells for Tissue Engineering,WIS,2006

Reference Books

1. Buddy D. Ratner Allan S. Hoffman Frederick J. Schoen Jack E. Lemons. Biomaterials Science, Second Edition: Wiley Science,2004.
2. Biomaterial. By Bhatt SV, Narosa publishing house
3. R. P. Lanza, R. Langerand W. L. Chick, Principles of tissue engineering, Academic press, 1997

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

GENOMICS, PROTEOMICS & METABOLOMICS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Honors**	**Course Code:**	**BT4171**

Prerequisites: Basics of Biochemistry, Molecular Biology, r-DNA Techniques

Course Outcomes:
On successful completion of this course, the students should be able to:

CO1: Explain the structure and function of genomes, using mapping and sequencing techniques.

CO2: Analyze the relationship between genome, genetics and its functioning.

CO3: Apply techniques to study proteins, protein expression and interactions

CO4: Apply different techniques to analyze metabolites and understand their role in biochemical pathways.

Module I **(8 Hours)**

Introduction to genomics: Orientation and structure of genomes; Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods, Genome Annotation. Structure, Human Genome sequencing project; Reverse genetics, Structural genomics, Functional genomics and Comparative genomics; High throughput screening in genome for drug discovery-identification of gene targets.

Module II **(8Hours)**

Introduction and tools of proteomics: Proteomics and Proteomes, Various tools used inproteomics (N-terminal sequencing of proteins, 2-D electrophoresis Differential display proteomics, Yeast two hybrid and three hybrid system, phage display, isoelectrofocusing, Peptide fingerprinting. Chromatography, LC/MS-MS for identification of proteins and modified proteins, SAGE, Protein micro array).

Module III **(6Hours)**

Sample preparation (fractionation, enrichment, derivatization), Applications of proteomics: Mining proteomes, protein expression profiling, identifying protein – protein Interactions and protein complexes, mapping- protein identification, new directions in proteomics, structural proteomics.

Module IV **(8Hours)**

Metabolomics-an overview, analysis by Mass Spectrometry, Profiling based on NMR, 2-D and high (spatial) resolution metabolite profiling, Quantitative metabolomics; Metabolite analysis, Engineered metabolism, Databases (Metabolic pathways resources) and pathway reconstruction.

Text Books:

1. Genomes, Brown TA, 3rd Edition. Garland Science
2. S. B. Primrose and R. M. Twyman*Principles of Gene Manipulation & Genomics*, Blackwell Publishing (2006) 7th Edition.
3. Fundamentals of Biochemistry, Voet D, Voet JG & Pratt CW, 2nd Edition. Wiley

Reference Books:

1. Discovering Genomics, Proteomics and Bioinformatics, Campbell AM &Heyer LJ, 2nd, Edition. Benjamin Cummings
2. Molecular Biotechnology, Glick BR & Pasternak JJ, 3rd Edition, ASM Press
3. R. Twyman, Principles of Proteomics, CRC Press (2013), 2nd Edition

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

DRUG DELIVERY SYSTEM			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Honors**	**Course Code:**	**BT4173**

Prerequisites: Basic knowledge of biophysics, biochemistry and transport processes.

Course Outcome:

On successful completion of this course the students should be able to:

CO1: Gains knowledge on the process of drug discovery and development.

CO2: Analysedrug-receptor interactions

CO3: Evaluate various drug delivery systems and their applications.

CO4: Investigate trends and regulatory aspects in drug design and delivery

Module I: (8 Hours)

Basics of Drug Design and discovery: Introduction to drug discovery and drug design, Sources of drugs: natural, synthetic, recombinant; Lead identification and lead optimization, Structure-activity relationships (SAR),Quantitative structure-activity relationships (QSAR), Introduction to computer-aided drug design (CADD). Molecular modeling: basics and applications,Target identification and validation (biological targets)

Module II: **(8 Hours)**

Principles of Drug Action : Mechanism of drug action: Receptor theory,Types of receptors and drug-receptor interactions; Drug selectivity and specificity,Pharmacokinetics: absorption, distribution, metabolism, excretion (ADME),Pharmacodynamics: dose-response relationships,Toxicity and drug safety (Therapeutic index), Drug metabolism and prodrug concept

Module III: (8 hours)

Principles of drug delivery, Routes of drug administration: oral, parenteral, transdermal, pulmonary, ocular, nasal, targeted delivery, Controlled and sustained release systemsNanotechnology-based drug delivery, Liposomes, nanoparticles, dendrimers, micellesSmart drug delivery systems,Case studies of advanced drug delivery systems

Module IV: (8 Hours)

Emerging Trends and Regulatory Aspects of Drug Delivery system:Artificial Intelligence and Machine Learning in drug design, High-throughput screening; Regulatory guidelines in drug design and delivery (FDA, EMA), Intellectual property rights (IPR) and patents,Ethical aspects of drug design, Recent advances and future directions in drug delivery.

Text Books

1. Drug Design: Structure- and Ligand-Based Approaches – Kenneth M. Merz Jr. et al.
2. An Introduction to Medicinal Chemistry – Graham L. Patrick
3. Drug Delivery and Targeting – A. Michael and S. J. Davis

Reference Books

1. 1.Drug Delivery: Principles and Applications – Binghe Wang, Teruna J. Siahaan, Richard A. Soltero
2. Pharmacokinetics and Pharmacodynamics of Drug Delivery – M. N. Goyal et al.
3. Research papers, regulatory guidelines (FDA, EMA, CDSCO)

Mapping of Course Outcomes with Program Outcomes (POs)

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

**3/2/1 indicates strength of correlation: 3 – High, 2 – Medium, 1 – Low*

INDUSTRIAL BIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Honors**	**Course Code:**	**BT4172**

Prerequisites: Fundamental knowledge in microbiology, Industrial microbiology and biochemistry

Course Outcomes:

On successful completion of this course the students should be able to:

CO1: Ability to understand the basic insights, operations and general aspects enzymes and microbes for the manufacturing of products.

CO2: Understanding the various fermentations and its uses for product formation.

CO3: Understanding the function and application of various bioproducts

CO4:Ability to understand various advanced biochemical methods and their roles in enzyme improvisation.

Module I (8 Hours)

Introduction to Industrial Biotechnology, its components and Microbes & enzymes of industrial importance. Microbial Processes and fermentation technology: Introduction to fermentation technology, Microbial growth and product formation kinetics in batch, continuous and fed batch fermentation, Large scale production: submerged, solid and semi-solid fermentation.

Module II (8 Hours)

Microbiological processes for industrial production of antibiotics; organic acids; polysaccharides; lipids; pigments; aromatic substances solvents; and enzymes. Bioenergy production, Microbial fuel cell and Industrial wastewater treatment processes.

Module III (8 Hours)

Commercial media and strain development: Media selection and development for industrial production, Isolation, selection, characterization of microorganisms, stock culture, development inocula, Strain improvement: induced mutation, over producing decontrolled mutants.

Module IV (8 Hours)

Stability of enzyme: Enzyme stabilization by selection and genetic engineering, protein

engineering. Application of Biocatalyst, Group transfer redox reaction, Elimination, isomerization and rearrangement, C-C bond cleavage, Chemical modification, intramolecular cross linking and immobilization

Text Books:

1. Principle of Fermentation Technology , P.F. Stanbury, A. Whitaker and S.J. Hall,Elsevier
2. Biochemical Engineering and Biotechnology Handbook, Atkinson, B and Marituna,F., The Nature Press, Macmillan Publ. Ltd.
3. Functional Foods and Biotechnology. K. Setty and D. Sarkar, CRC Press. McGraw Hill Publisher

Reference Books:

1. Advances in Agricultural and Industrial Microbiology- S.K. Nayak, B. Baliyarsingh, A. Singh, I. Manazzu and B.B. Mishra, SpringerNature, 2022
2. Environmental Biotechnology: Principles and Applications- Rittman and McCarty, McGrawHill

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMATERIALS AND TISSUE ENGINEERING LAB			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Honors Laboratory**	**Course Code:**	**BT3572**

Prerequisites: Basic knowledge of biomaterials and tissue engineering

Course Outcomes (COs):

CO1: Design and conduct experiments/analyze data related to biomaterials synthesis and characterization.

CO2: Apply the techniques, skills, and modern engineering tools needed for tissue engineering practice.

CO3: Isolate primary cells and implement 3D cell culture strategies for tissue engineering.

CO4: Evaluate biomaterials for tissue engineering applications and analyze engineered tissues using histological and immune-cytochemistry techniques.

List of Experiments

(Any 8 experiments can be done)

1. Study of Biomaterials types and prioperties.
2. Synthesis and Fabrication of Biomaterials
3. Characterization of Mechanical Properties of biomaterials.
4. FTIR Characterization of Biomaterials.
5. Optical Microscopy and Quantitative Image Analysis using Scanning Electron Microscopy
6. Preparation of Scaffolds for 3D Cell Culture by fabricating scaffolds using materials like collagen, gelatin, or chitosan, followed by sterilization and characterization of scaffold properties.
7. Seeding of Cells onto Scaffolds and Monitoringl attachment, growth, and proliferation using microscopy.
8. Tensile Testing of Biomaterials Using Instron Mechanical Tester.
9. Basic Biomaterial Characterization including mechanical testing such as compression testing, porosity measurements. Andsurface morphology study using SEM
10. Histological Staining and Immunocytochemistry by usngHematoxylin and Eosin (H&E) staining of tissue sections to observe tissue architecture using fluorescence microscopy

Text Books:

1. Principles of Tissue Engineering by Robert Lanza, Robert Langer, and Joseph Vacanti
2. Tissue Engineering by Bernhard O. Palsson and Sangeeta N. Bhatia

3. Biomaterials Science: An Introduction to Materials in Medicine by Buddy D. Ratner et al.

Reference Books:

4. Fundamentals of Tissue Engineering and Regenerative Medicine by Ulrich Meyer et al.
5. Cell and Tissue Engineering by C.W. Patrick et al.
6. Biomaterials for Tissue Engineering Applications by Bartolo, Patrício, and Chua
7. Essentials of Stem Cell Biology by Robert Lanza

Mapping of Course Outcomes with Program Outcomes (POs)

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

**3/2/1 indicates strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMOLECULAR MODELING & SIMULATION LABORATORY			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Honors Laboratory**	**Course Code:**	**BT4571**

Prerequisites: Basic knowledge of biological systems, cell and molecular biology, databases and computer programming.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: To quantitatively understand the structure, function of various biomolecules using computational modelling and simulation tools.

CO2: To apply mathematical modeling and numerical methods for simulating complex biological processes at various levels (from single molecule to protein/whole cell).

CO3: To analyze and interpret the functions of macromolecules based on structural information available in various databases.

CO4: To apply the concepts and tools of molecular dynamics simulation and molecular visualization in translational and biomedical research.

List of Experiments

(Any 8 experiments can be done)

1. Molecular Visualization using Pymol and Chimera: Pdb file format and Parsing, Visualizing a molecule in different representations, Identifying interacting residues (protein and ligand interactions).
2. Molecular Visualization and Analysis using Pymol and Chimera: Measuring distances between atoms and B-factor visualization, Image tracing and preparation methods.
3. Small Molecule sketching using Marvin sketch and bond optimization in 2D & 3D format (SDF, MOL2 file formats).
4. Geometry Optimization using SwissPdb Viewer (Energy Minimization of protein molecule, Determining Maxima and Minima energy points).
5. Binding Site Identification (Different approaches for binding site identification e.g., Tools - Cast-P, POCASA, 3D ligand site, Metapocket, Ghecom).
6. Structure based Drug design: Molecular docking using Auto Dock (protein-ligand & protein-protein interaction).
7. Virtual Screening using Auto Dock Vina (potential small molecule and drug compounds).
8. Molecular Dynamics Simulation using Gromacs
9. Protein-ligand complex MD simulation
10. Ligand Based drug design : QSAR

Text Books:

1. Computational Chemistry and Molecular Modeling-Principles and Applications by Ramachandran, Deepa and Namboori, 2008, Springer_Verlag. Reference for Unit 1 and 2.

2. Molecular Modeling Principles and Applications (2nd Ed.) by Andrew R. Leach, Prentice Hall, USA. 2001

Reference Books:

1. Molecular Modelling for Beginners, (2nd Edition) by Alan Hinchliffe, John Wiley & Sons Ltd. 2008

2. Molecular Modeling and Simulation – An interdisciplinary Guide by Tamar Schlick, Springerverlag. 2000

3. Computational medicinal chemistry for drug discovery edited by Patrick Bultinck, Marcel Dekker Inc. 2004

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

COURSE STRUCTURE FOR MINOR DEGREE

IN

BIOMEDICAL ENGINEERING (BME)

(5^{th} – 8^{th} *SEMESTERS*)

Sl. No.	Semester	Course Code	Subject (Theory)	Contact Hrs L-T-P	Credit
1	**5th**	BT3261	Basics of Human Anatomy and Physiology	3-0-0	3
2	**6th**	BT3262	Biomaterials and Tissue Engineering	3-0-0	3
3	**7th**	BT4261	Biomedical Signal Processing	3-0-0	3
4	**7th**	BT4263	Fundamentals of Medical Instrumentation	3-0-0	3
5	**8th**	BT4262	Biomechanics	3-0-0	3
Subject (Sessional)					
6	**6th**	BT3562	Biomaterials and Tissue Engineering Lab	0-0-3	1.5
7	**7th**	BT3561	Medical Instrumentation Lab	0-0-3	1.5

Syllabus

BASICS OF HUMAN ANATOMY AND PHYSIOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Minor**	**Course Code:**	**BT3261**

Prerequisites: Basic knowledge of biology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand the gross anatomy and physiology of the human body.

CO2: Analyze the concepts and engineering principles that can be applied or derived from the anatomy and physiology of the human body.

CO3: Implement the knowledge of biophysics and biochemistry of the human body during health and diseased conditions in day-to-day life to design new diagnostic tools.

CO4: Apply the principles of engineering, mathematics and physics to obtain a quantitative understanding of cellular, tissue and organ function in health and disease.

Module I **(6 Hours)**

Introduction to Anatomy and Physiology, Organisation of the living system, Homeostasis and System Integration, Positive Feedback Loop in Homeostasis, Chemical Basis of Organisation of the body

Module-II **(8 Hours)**

Classification of bones, joints, Bones of limbs and major muscles of limbs and their actions, Skeletal muscle, Structure, Mechanism of muscle contraction, types of contraction, smooth muscle classification, mechanism of smooth muscle of contraction, Structure & function of Heart & blood vessels, Special functional tissue of heart, E. C. G., Cardiac cycle, Blood – composition, function, blood group, blood clotting, blood pressure regulation, CO measurement methods, Controlling factors, and Lymphatic system: Spleen, glands and lymph nodes, Upper and lower respiratory tract, Structure and Function of respiratory membrane, Pulmonary circulation, Mechanics of breathing, Transport and control of gases, Lungs volume and capacities, Regulation of respiration, Pulmonary function tests

Module-III **(8 Hours)**

Brain and spinal cord, peripheral autonomic nervous system, nerve physiology, Stretch Reflex Phenomena, Structure and Circuit of Neurons, Excitability in Cell, Ion Transportation in Cell, Signal Propagation in Neuron, Neurotransmitter and Action Potential, Epilepsy and Memory, Length Tension Relation of Skeletal Muscle

Module-IV **(8 hours)**

Endocrine Glands: types, location, description, and functions, Parts of the digestive system, Gastrointestinal tract and associated glands, Parts and functions of the urinary system, Kidney and the Immune System, Male and female reproductive system. Mathematical and computational approaches to Physiology.

Text Books:

4. Guyton and Hall, Text Book of Medical Physiology, 2ND ed., 2004
5. Ganong'S Rev of Med Physiology, McGraw Hill, 2016.
6. Fundamentals of Anatomy & Physiology, 11th edition, Global edition, by Martini, Nath, and Bartholomew, Pearson, 2018.

Reference Books

3. K. Saladin, Anatomy & Physiology: The Unity of Form and Function, McGraw-Hill College, 7th edition,2014.
4. R. Drake, A. W. Vogl, Adam W. M. Mitchell, and R. Tibbitts, Gray's Atlas of Anatomy, Churchill Livingston, 2nd edition, 2014.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMEDICAL SIGNALS PROCESSING			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Minor**	**Course Code:**	**BT3262**

Prerequisites: Basic knowledge of biology, physics, and mathematics.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Define and describe types of biomedical signals in mathematical terms (periodic, non-periodic, and random) and their sources at the cell, tissue, and organ levels.

CO2: Identify the sources, types &characteristics of different noises and artefacts present in biomedical signals.

CO3: Analyze digital signals and construct digital filters for noise and artifact removal from biomedical signals.

CO4: Explore alternative techniques of analyzing Biomedical Signals and apply a model-based analysis to selected physiological signals.

Module I **(8 Hours)**

Introduction to Biomedical Signals: Action Potential and Its Generation, Origin and Waveform Characteristics of Basic Biomedical Signals Like: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis.

Module II **(8 Hours)**

Removal of Noise and Artifacts from Biomedical Signal:Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Noises and Artefacts Present in ECG, Time and Frequency Domain Filtering.

Module III **(8 hours)**

EEG Signal Processing and Event Detection in Biomedical Signals: EEG Signal and Its Characteristics, EEG Analysis, Linear Prediction Theory, Autoregressive Method, Sleep EEG, Application of Adaptive Filter for Noise Cancellation in ECG and EEG Signals; Detection of P, Q, R, S and T Waves in ECG, EEG Rhythms, Waves and Transients, Detection of Waves and Transients, Correlation Analysis Ad Coherence Analysis of EEG Channels.

Module IV **(8 hours)**

Analysis of Nonstationary Signals: Heart Sounds and Murmurs, Characterization of Nonstationary Signals and Dynamic Systems, Short-Time Fourier Transform, Considerations in Short-Time Analysis and Adaptive Segmentation; case study.

Text Books:

1. Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons.
2. Reddy, D.C., 2005. Biomedical signal processing: principles and techniques. McGraw-Hill .

Reference Books

1. TompkinTompkins, W.J., 1993. Biomedical digital signal processing. Editorial Prentice Hall.
2. Sörnmo, L. and Laguna, P., 2005. Bioelectrical signal processing in cardiac and neurological applications (Vol. 8). Academic Press.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

FUNDAMENTALS OF MEDICAL INSTRUMENTATION			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Minor**	**Course Code:**	**BT4261**

Prerequisites: Basic knowledge of physics and principles of electrical sciences.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Define commonly used technical terms from Medicine and Biomedical Engineering.

CO2: Describe the engineering principles of commonly used medical devices and medicalimaging systems.

CO3: Describe the engineering principles of commonly used medical devices and medicalimaging systems

CO4: Realize safety requirements of biomedical instrumentation.

Module I **(8 Hours)**

Components of Medical Instruments: Basic Medical Instrumentation System, Static and dynamic characteristics of medical instruments, Bio-signals and characteristics. Problems encountered with measurements from human beings. Bio potential Electrodes: Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode–Skin interface, half cell potential, impedance, polarization effects of electrode –non-polarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes.

Module II **(8 Hours)**

Electrode configuration: Biosignals characteristics – frequency and amplitude ranges. ECG – Einthoven's triangle, standard 12 lead system. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG, ERG and EOG – unipolar and bipolar mode. Bioamplifier: Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier – right leg driven ECG amplifier. Band pass filtering, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier. Chopper amplifier. Power line interference.

Module III **(8 Hours)**

Measurement of Nonelectrical Parameters: Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods - auscultatory method, oscillometric method, direct methods: electronic manometer, Pressure amplifiers - systolic, diastolic, mean detector circuit. Blood flow and cardiac output measurement: Indicator dilution, thermal dilution and dyedilution method, Electromagnetic and ultrasound blood flow measurement.

Module IV **(8 Hours)**

Biochemical sensors - pH, pO2 and pCo2, Ion selective Field effect Transistor (ISFET),Immunologically sensitive FET (IMFET), Blood glucose sensors - Blood gas analyzers,colorimeter, flame photometer, spectrophotometer, blood cell counter, auto analyzer(simplified schematic description).

Text Books:

1. John G. Webster, "Medical Instrumentation Application and Design", John Wileyand sons, New York, 2004
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical EquipmentTechnology", Pearson Education, 2004.

3. Leslie Cromwell, “Biomedical Instrumentation and measurement”, Prentice hall ofIndia, New Delhi, 2007.

Reference Books:

1. R.S. Khandpur, “Hand-book of Biomedical Instrumentation”, TMH, 2nd Ed., 2003.
2. Bio-Medical Electronics and Instrumentation, Onkar N. Pandey, Rakesh Kumar,Katson Books.
3. Dr. M. Arumugam, “Biomedical Instrumentation”, Anuradha publications, 2nd ed., 1994.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMECHANICS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Minor**	**Course Code:**	**BT4263**

Prerequisites: Basic knowledge of biology and physics

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Gain knowledge on the basic biomechanical principles and their application in biological systems.

CO2: Analyze the interplay between mechanical forces and biological responses, focusing on tissue mechanics and cellular behavior.

CO3: Implement the understanding of biomechanics at the molecular and continuum levels, integrating advanced material properties and experimental techniques.

CO4: Implement the subject knowledge to solve static and dynamic problems in biomechanics

Module I **(8 Hours)**

Bio-fluid Mechanics: Newton's Law; Stress, Strain, Elasticity; Hooke's Law; Viscosity;Newtonian Fluid; Non-Newtonian Fluid; Viscoelastic Fluids; Velocity and Pressure ofBlood Flow; Resistance Against Flow.Viscoelasticity: Viscoelastic models – Maxwell-Voigt and Kelvin Models – Response to Harmonic variation – Use of viscoelastic models – Bio-Viscoelastic fluids: Protoplasm – Mucus – Saliva –Synovial fluids.

ModuleII **(8 Hours)**

Physical – Chemical and Rheological properties of blood – Apparent and relative viscosity – Bloodviscosity variation – Effect of shear rate, haematocrit, temperature, protein contents of blood –Casson's equation – Problems associated with extracorporeal blood flow – Rheology of Blood in micro-vessels – Fahraeus-Lindquist effect and inverse effect – Distribution of suspended particles in a narrow rigid tube – Nature of red blood cells in tightly fitting tubes – Hematocrit in very narrow tube.

Module III **(8Hours)**

Kinematics – Descriptions of Motion, Kinetics – Introduction to Forces – Introduction to Statics and Dynamics – Translatory Motion in Linear and Concurrent Force Systems – Additional Linear Force Considerations – Rotatory and Translatory Forces and Motion – Torque – Moment of Force – Muscle Forces – Lever Systems – Force Components – FEM – FEA. Viscoelastic media – Viscoelasticity in bone – Bone fractures – Biomechanics of bone – Posture and Gait – Normal and Pathological. Material components of the body: Ligaments – Tendons – Cartilage – Elastic properties – Energy storage in elastic media –Viscoelasticity in muscles – Total muscle tension – Muscle fatigue.

ModuleIV **(8 Hours)**

Cardiovascular system – Mechanical properties of blood vessels – Arteries – Arterioles – Capillaries and veins – Blood flow: Laminar and Turbulent – Physics of cardiovascular diseases – Prosthetic heart valves and replacements; Structure of heart – Heart valves – Mechanical modeling

of vasculatures and stent – Structure of the lung –Physics of breathing – Alveoli – Mechanical model of breathing and breathing parameters –Methods for determining lung pressure and volume – Airway resistance and conductance.

Text Books:

1. NihatOzkaya and Margareta Nordin, Fundamentals of biomechanics: Equilibrium, Motion and deformation, 2nd Edi. Springer , 1999.
2. Y.C Fung, Biomechanics – Mechanical Properties of Living Tissues, Springer,1993.

Reference Books

1. Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, Taylor and Francis , 2007
2. Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon, Introduction to Cell Mechanics and Mechanobiology, Garland Science , 2012

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

Biomaterials And Tissue Engineering			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Minor**	**Course Code:**	**BT4262**

Prerequisites: Fundamentals of human anatomy and physiology

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Gain knowledge of biomaterial interactions with cells, tissues, and the host body

CO2: Understand the concepts of cell-scaffold interactions, growth factor signaling, and the role of biomaterials in tissue development.

CO3: Apply engineering principles to design and optimize biomaterials for specific applications.

CO4: Fabricate biomedical implants and tissue-engineered products for modern approaches to surgery and prosthetics.

Module I **(8 Hours)**

Introduction to biomaterials and Concept of biocompatibility; Structural properties (mechanical, thermal, optical, electrical and surface properties) of biomaterials;Properties of Biomaterials: Electrical Properties & Piezoelectricity, Optical Properties, X-ray Absorption, Acoustic Properties, Density & Porosity Diffusion Properties. Characterization of Mechanical properties: Stress-Strain Behavior, Mechanical Failure: Static & Dynamic Failure, Friction & wear failure, Visco-Elastic material behaviour;Assessment of biocompatibility of biomaterials.

Module-II **(8 Hours)**

Metallic Biomaterials: Introduction & Implants materials, metallic implants, stainless steels, CoCr Alloys, Ti Alloys, hydroxyapatite glass, Corrosion of metallic Implants. Hydrogels, self-assembling peptides, 2D and 3D matrices (scaffolds) of biomaterials for tissue engineering, Soft tissue and hard tissue replacement, cardiovascular implants, Biomaterials for ophthalmology, orthopaedic and dental implants.

Module-III **(8 Hours)**

Ceramic Biomaterials: Introduction, Non-absorbable materials like Alumina, Carbons & Zirconia, Biodegradable Ceramics like Calcium phosphate, Aluminum-Calcium-Phosphate (ALCAP) Ceramics. Bioactive ceramics like Glass ceramics, Polymeric Biomaterials-Introduction, Polymerization & Basic structure, physicochemical properties of polymers, Polymers used as Biomaterials: Polyvinylchloride (PVC), Polyethylene (PE), Plolymethylmetacrylate (PMMA). Polymers for drug delivery. Composite Biomaterials-Structure, Bounds & Properties, Anisotropy of Composites, Particulate Composites, Fibrous Composites & Porous Materials. Design concept of developing new materials for bio-implant applications

Module-IV **(8 Hours)**

Elements for tissue engineering: cells, matrices, and biochemical/physical factors. Stem cells and differentiation. Biomaterials used and aspects related to the three-dimensionality of substrates. Chemical and mechanical stimuli. Scaffold: Concept and functions, Scaffold Properties-physico-

chemical-mechanical and biological; Scaffold: Scaffold Design and Fabrication- conventional and advanced techniques for 2D and 3D design, Scaffold Characterization techniques, Cell- scaffold integration: Introduction, cell seeding techniques, Cell-scaffold interaction- cell adhesion, cell proliferation, cell migration and cell agglomeration, Assessment of tissue construct, Ethical and regulatory issues.

Text Books:

1. Biomaterials - An Introduction, 3 Ed.Joon Park &R.S.Lakes-Springer
2. Biomaterials- Joyce Y.Wong& Joseph D. Bronzino – CRC Press
3. G. Vunjak-Novakovic, R. Ian Freshney, Culture of Cells for Tissue Engineering,WIS,2006

Reference Books

1. Buddy D. Ratner Allan S. Hoffman Frederick J. Schoen Jack E. Lemons. Biomaterials Science, Second Edition: Wiley Science,2004.
2. Biomaterial. By Bhatt SV, Narosa publishing house
3. R. P. Lanza, R. Langerand W. L. Chick, Principles of tissue engineering, Academic press, 1997

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

Medical Instrumentation Lab			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Minor Laboratory**	**Course Code:**	**BT3562**

Prerequisites: Basic knowledge of biomedical instruments and measurement methods.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Study the operation of various biomedical instruments and transducers
CO2: Get exposure to human body parameter measurement.
CO3: Handle various medical instruments essential to measure several physiological signals.
CO4: Develop understanding of patient monitoring systems.

List of Experiments

(Any 8 experiments can be done)

1. Perform the measurements based on transducers and plot the characteristics
2. Compare performance of variety of electrodes
3. Measurement of Blood Pressure
4. Measurement of pH
5. Analyze Instrumentation amplifier for biomedical signals
6. Learn pulse oximeter/Diathermy
7. Simulate the real time ECG monitoring and ECG wave analysis
8. Simulate the real time EEG monitoring and EEG wave analysis
9. Observe the real time patient monitoring system (Visit to Hospital)
10. Observe of pacemakers/ defibrillators/Ventilators/MRI/X-ray(Visit to Hospital)

Text Books:

1. John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2004
2. Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.

Reference Books:

1. R.S. Khandpur, "Hand-book of Biomedical Instrumentation", TMH, 2nd Ed., 2003.
2. Bio-Medical Electronics and Instrumentation, Onkar N. Pandey, Rakesh Kumar, Katson Books.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMATERIALS AND TISSUE ENGINEERING LAB			
Hours/Week L-T-P:	**0-0-3**	**Credits:**	**1.5**
Course Type:	**Minor Laboratory**	**Course Code:**	**BT3561**

Prerequisites: Basic knowledge of biomaterials and tissue engineering

Course Outcomes (COs):

CO1: Design and conduct experiments/analyze data related to biomaterials synthesis and characterization.

CO2: Apply the techniques, skills, and modern engineering tools needed for tissue engineering practice.

CO3: Isolate primary cells and implement 3D cell culture strategies for tissue engineering.

CO4: Evaluate biomaterials for tissue engineering applications and analyze engineered tissues using histological and immunocytochemistry techniques.

List of Experiments

(Any 8 experiments can be done)

1. Study of Biomaterials types and prioperties.
2. Synthesis and Fabrication of Biomaterials
3. Characterization of Mechanical Properties of biomaterials.
4. FTIR Characterization of Biomaterials.
5. Optical Microscopy and Quantitative Image Analysis using Scanning Electron Microscopy
6. Preparation of Scaffolds for 3D Cell Culture by fabricating scaffolds using materials like collagen, gelatin, or chitosan, followed by sterilization and characterization of scaffold properties.
7. Seeding of Cells onto Scaffolds and Monitoringl attachment, growth, and proliferation using microscopy.
8. Tensile Testing of Biomaterials Using Instron Mechanical Tester.
9. Basic Biomaterial Characterization including mechanical testing such as compression testing, porosity measurements. Andsurface morphology study using SEM
10. Histological Staining and Immunocytochemistry by usngHematoxylin and Eosin (H&E) staining of tissue sections to observe tissue architecture using fluorescence microscopy

Text Books:

1. Principles of Tissue Engineering by Robert Lanza, Robert Langer, and Joseph Vacanti
2. Tissue Engineering by Bernhard O. Palsson and Sangeeta N. Bhatia
3. Biomaterials Science: An Introduction to Materials in Medicine by Buddy D. Ratner et al.

Reference Books:

1. Fundamentals of Tissue Engineering & Regenerative Medicine by Ulrich Meyer et al.
2. Cell and Tissue Engineering by C.W. Patrick et al.
3. Biomaterials for Tissue Engineering Applications by Bartolo, Patrício, and Chua
4. Essentials of Stem Cell Biology by Robert Lanza

Mapping of Course Outcomes with Program Outcomes (POs)

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

**3/2/1 indicates strength of correlation: 3 – High, 2 – Medium, 1 – Low*

Open Electives Offered
by Department of Biotechnology

Sl. No.	Semester	Course Code	Subject (Theory)	Contact Hrs L-T-P	Credit
1	**7th (OE1)**	BT4301	Nanomedicine and Nanobiotechnology	3-0-0	3
2	**8th (OE2)**	BT4302	Basics of Industrial Biotechnology	3-0-0	3
3	**8th (OE3)**	BT4304	Biology for Engineers	3-0-0	3
4	**8th (OE4)**	BT4306	Biomedical Data Acquisition & Management	3-0-0	3

Syllabus

NANOMEDICINE AND NANOBIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Open Elective**	**Course Code:**	**BT4301**

Prerequisites: Basic knowledge of biology, physical chemistry

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand the fundamental principles and unique properties of nanomaterials and their relevance in biology.

CO2: Explain synthesis methods, structural principles, and functionalization strategies in nanobiotechnology.

CO3: Analyze the applications of nanomaterials in medicine, including drug delivery systems and diagnostic devices, highlighting their advantages over conventional technologies.

CO4: Evaluate case studies on nanomedicine, assess nanotoxicology and bio-nano interactions.

Module I **(8 Hours)**

Definition and history of nanotechnology and nanobiotechnology, Understanding the nanoscale, Unique properties of nanomaterials (size, surface area), Phase transformation in nanomaterials, mechanical properties of nanomaterials Biological molecules as nanomaterials: proteins, DNA, lipids, carbohydrates.

Module-II **(8 Hours)**

Top-down vs. bottom-up approaches, Structural and functional principles guiding the nanostructures design, DNA hybridization, protein folding, Micelle and liposome formation Overview synthesis of nanomaterials: physical, chemical, and biological methods (sol-gel, microemulsion, green synthesis using plants or microbes). Surface functionalization, targeting, bioconjugation.

Module-III **(8 Hours)**

Basic concepts in the design of nanomedicine, Advantages over conventional medicine, Nanoparticles in drug delivery: passive and active targeting, encapsulation (Liposomes, dendrimers, polymeric NPs), Nanotechnology in diagnostics: biosensors, imaging agents, lab-on-a-chip devices.

Module-IV **(6 hours)**

Case studies of disease detection and therapy, Nanotoxicology: health and environmental risks, safe-by-design approaches, Nano–bio interactions and immunological concerns, Emerging Trends-Artificial nanorobots and smart drug systems.

Text Books:

7. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013
8. Understanding Nanomedicine: An Introductory Textbook Rob Burgess, CRC Press, 2012.
9. Nanomedicine: Design and Applications" by Tuan Vo-Dinh

Reference Books

1. Bionanotechnology by David S. Goodsell, 2004, Wiley Publications
2. Nanomedicine for Cancer Therapy: From Chemotherapeutic to Hyperthermia-Based Therapy , Springer, Piyush Kumar, RohitSrivastava, 2017
3. Nanotoxicology, Materials, Methodologies, and Assessments, Editors: Durán, Nelson, Guterres, Silvia S., Alves, OswaldoLuiz (Eds.),

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BASICS OF INDUSTRIAL BIOTECHNOLOGY			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Open Elective**	**Course Code:**	**BT4302**

Prerequisites: Fundamental knowledge in microbiology, Industrial microbiology and biochemistry

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Understand the various industrial fermentations and its uses for product formation.

CO2: Explain various function and application of various bio-products.

CO3: Analyze advanced biochemical methods and their roles in enzyme improvisation.

CO4: Apply the suitable microbes in food industry and its regulation in usages.

Module I **(8 Hours)**

Introduction to industrial biotechnology and fermentation industry, Scope of microbiology, Microbes & enzymes of industrial importance. Fermentation Industry and role of microbes in fermentation, Isolation, selection, characterization of microorganisms, stock culture, development inocula, Strain improvement.

Module-II **(8 Hours)**

Essentials of fermentation production process: fermentation media, aeration, pH, temperature, Types of culture: Batch, Continuous culture and fed batch fermentation, Overview of downstream process engineering and product recovery. Large scale production: submerged, solid and semi-solid fermentation. Maintenance and preservation of industrially important microbial cultures.

Module-III **(8 Hours)**

Microbiological processes for industrial production of antibiotics; organic acids; polysaccharides; lipids; pigments; aromatic substances solvents; and enzymes. Bioenergy production, Microbial fuel cell and Industrial wastewater treatment processes.

Module-IV **(6 Hours)**

Microbiological Production of Food and food products: Fermented dairy products, Fermented meats, Leavening of breads, Alcoholic beverages, Fermented vegetables, Single Cell Protein. Biotechnology programmes and regulation, Regulation for disposal of biohazardous materials. Mycotoxins, hazards in the production of fungal products. Health hazards during microbial spoilage, teratogenic biologicals.

Text Books:

4. Functional Foods and Biotechnology. K. Setty and D. Sarkar, CRC Press. McGraw Hill Publisher.
5. Industrial Microbiology. Casida L.E. New Age Publication, New Delhi, India. 2010
6. Principle of Fermentation Technology , P.F. Stanbury, A. Whitaker and S.J. Hall, Elsevier

Reference Books

4. Industrial Microbiology. Patel A.H. New Age International Publishers. 2007
5. Advances in Agricultural and Industrial Microbiology - S.K. Nayak, B. Baliyarsingh, A. Singh, I. Manazzu and B.B. Mishra, Springer Nature, 2022

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOLOGY FOR ENGINEERS			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Open Elective**	**Course Code:**	**BT4304**

Prerequisites: Fundamentals of Basic Biology and Chemistry

Course Outcomes:
On successful completion of this course, the students should be able to:

- **CO1:** Explain the fundamental concepts of biology, biological classification, and model organisms with their significance.
- **CO2:** Describe genetic principles, biomolecule structure and function, and chromosomal aberrations with relevance to biology.
- **CO3:** Analyze enzyme properties, catalytic mechanisms, and techniques for protein separation and characterization
- **CO4:** Interpret metabolic pathways, microbial classification, and the role of microorganisms in biological and applied contexts.

Module I **(8 Hours)**

Introduction to biology: fundamentals, similarities and differences, philosophy of biology, observations and important discoveries in biology, Hierarchy of life forms, traditional, biological, ultrastructure of prokaryotes and eukaryotes, five kingdom classification system, molecular taxonomy, model organisms and their applications.

Module II **(8 Hours)**

Introduction to Genetics, Laws of Inheritance, Concept of Allele, Gene mapping and Interaction; Chromosomal abnormalities and syndromes, Structural organization of complex biomolecules, Monomers & Polymers, Classification Structure: Amino acids, Proteins, Carbohydrates, Nucleic Acids, Lipids.

Module III **(6 Hours)**

Introduction to Enzymes and Protiens, Classification, metal ions and cofactors, isozymes, mechanism of enzyme action, kinetics of enzyme-catalyzed reaction, Enzyme inhibition, Allosteric enzymes; Analysis of proteins, Chromatographic, Electrophoretic techniques, Protein Assays, Properties of proteins, Structure and function of proteins.

Module IV **(8 Hours)**

Metabolism in Biological systems, Activated Carriers of Electrons, Concept of Energy charge, Oxidation and Reduction Reactions; Cellular respiration, Glycolysis, Krebs cycle/Citric acid cycle, Electron transport chain, Photosynthesis, Difference between cellular respiration and photosynthesis. Single-cell organisms, concept of species and strain, identification and classification of microorganisms, microscopy, culturing of microorganisms in the lab, Different fields and applications of microbiology

Text Books:

4. Biology for Engineers, By Arthur T. Johnson, CRC Press. 2011
5. The Basics of Biology. S. Carol Leth. The United Kingdom, Greenwood Press, 2004.
6. Biology for Engineers, Annamma Odaneth and N. Ravi Sundaresan, All India Council for Technical Education, New Delhi. 2018

Reference Books:

4. Lehninger Principles of Biochemistry. Nelson, D. L., & Cox, M. M., (Sixth Edition). (2013). Macmillan Learning.
5. Principles and Techniques of Biochemistry and Molecular Biology.Wilson, K., & Walker, J., (2010). (Seventh Edition). Cambridge University Press.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**Strength of correlation: 3 – High, 2 – Medium, 1 – Low*

BIOMEDICAL DATA ACQUISITION & MANAGEMENT			
Hours/Week L-T-P:	**3-0-0**	**Credits:**	**3**
Course Type:	**Open Elective**	**Course Code:**	**BT4306**

Prerequisites: Basic knowledge of biology and databases.

Course Outcome:

On successful completion of this course the students should be able to:

CO1: Understand the fundamental biomedical data acquisition and management.

CO2: Analyze the connection between pertinent technologies and real-world medical problems.

CO3: Exposure to the wide range of applications using analytics and informed decision making.

CO4: Evaluate trends like Artificial Intelligence and Machine Learning in navigating big data challenges in healthcare practices.

Module I: **(10 Hours)**

Introduction to Biomedical Data: Overview of biomedical data and its analysis, basics of statistics in relation to biomedical data analysis- data distributions, continuous and discrete data, data representation, normality test, descriptive statistics, inferential statistics, receiver-operating-characteristic (ROC) curve analysis, correlations, Pre-processing of data, qualitative, and quantitative analysis, Principles of biomedical sensors, instruments, and real-time signal processing. Biosensor technologies (wearables, implantable) for continuous signal monitoring.

Module II: **(4 Hours)**

Data Management in Biomedical Engineering: Health information systems, Electronic Health Records (EHR), and big data analytics. Security, privacy, and ethical considerations in managing patient information.

Module III: **(8 hours)**

Biomedical Data Integration and Analytics: Techniques for Integrating Diverse Biomedical Data Sources. Data warehouses, analytics, and machine learning for predictive modeling. Patient-centric data integration, clinical trials, and research data management.

Module IV: **(8 Hours)**

Emerging Trends and Applications: Artificial Intelligence and Machine Learning algorithms for real-time biomedical data analysis; big data challenges and opportunities in biomedical engineering; medical imaging data management and integration; Biomedical data security; tele medicine; and ethical considerations in biomedical data.

Text Books

4. Edward H. Shortliffe, James J. Cimino, “Biomedical Informatics: Computer Applications in Health Care and Biomedicine,” 4th Edition, Springer, 2014.

5. Robert E. Hoyt, Ann K. Yoshihashi, “Health Informatics: Practical Guide for Healthcare and Information Technology Professionals,” 7th Edition, Lulu, 2021Drug

Reference Books

4. Arnon Cohen, Israel Gannot, “Biomedical Signal Processing and Signal Modeling,” CRC Press, 2022.

5. Sergio Manzi, Riccardo Rizzo, “Big Data in Healthcare: Statistical Analysis of Features in Selected Datasets,” SpringerBriefs in Pharmaceutical Science & Drug Development, Springer, 2020.

Mapping of Course Outcomes with Program Outcomes (POs)

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

**3/2/1 indicates strength of correlation: 3 – High, 2 – Medium, 1 – Low*