PANJAB UNIVERSITY

Scheme and Syllabus of
B.E. (Biotechnology)
3rd to 8th semester

2016-2017

University Institute of Engineering and Technology,

Panjab University, Chandigarh

DEPARTMENT **BIOTECHNOLOGY ENGINEERING**

VISION To nurture world- class bioengineers with a potential to innovate, invent and disseminate knowledge for the benefit of society and environment.

MISSION

1. Regular updation of the course curriculum to cater to the needs of academia and industry.
2. Initiate multi-disciplinary programs through academia-industry interface with special emphasis on implementation of bioprocess design and scale –up.
3. Emphasis on recent trends in bioengineering through organization of conferences, symposia, workshops.
4. Starting dedicated Postgraduate Programmes (M.Tech, PhD, M.Tech-PhD Integrated Programme).
5. Faculty development programmes to nurture world- class bioengineers with a potential to innovate, invent and disseminate knowledge for the benefit of society and environment.

PROGRAMME **B.E. Biotechnology (UG PROGRAMME)**

PROGRAMME EDUCATIONAL OBJECTIVES

Program Educational Objectives of the UG Biotechnology branch are:

1. PEO1- Our graduates will contribute to the field of biotechnology and alliedindustries designing, developing and providing solutions for product/processes/technology development.
2. PEO2- Work as entrepreneurs and techno managers with strong ethics and communication skills.
3. PEO3- Pursue higher education and research in reputed institute in national and international level.

PROGRAMME OUTCOMES

1. Graduates will gain and apply knowledge of Biotechnology, Science and Engineering concepts to solve problems related to field of Biotechnology.

2. Graduates will be able to identify, analyze and understand problems related to biotechnology Engineering and finding valid conclusions with basic knowledge in biotechnology Engineering.

3. Graduates will be able to design and develop solution to Biotechnology Engineering problems by applying appropriate tools while keeping in mind safety factor for environmental & society.

4. Graduates will be able design, perform experiments, analyze and interpret data for investigating complex problems in biotechnology Engineering and related fields.

5. Graduates will be able to decide and apply appropriate tools and techniques in biotechnological manipulation.

6. Graduates will be able to justify societal, health, safety and legal issues and understand his responsibilities in biotechnological engineering practices

7. Graduates will be able to understand the need and impact of biotechnological solutions on environment and societal context keeping in view need for sustainable solution.

8. Graduates will have knowledge and understanding of related norms and ethics in Biotechnology Engineering product/technique development.

9. Graduates will be able to undertake any responsibility as an individual and as a team in a multidisciplinary environment.

10. Graduates will develop oral and written communication skills.

11. Graduates will have thorough knowledge in Biotechnology Engineering and will also be ready to engage themselves in lifelong learning.

12. Graduates will be able to demonstrate knowledge of project and finance management when dealing with Biotechnology Engineering problems.

SCHEME OF EXAMINATION OF B.E. BIOTECHNOLOGY

Second Year - Third Semester

Sub Code	Subject	Scheme of Teaching					Scheme of Examination		
							Theory/ Practical		
		L	T	P	Hrs	Credits	Sess.	Univ. Exam.	Total
BIO 311	Process Calculations	4	0	0	4	4	50	50	100
BIO 312	Microbiology	4	0	0	4	4	50	50	100
BIO 362	Microbiology (Prac.)	0	0	3	3	2	50*	00	50
BIO 313	Biochemistry	4	0	0	4	4	50	50	100
BIO 363	Biochemistry (Prac.)	0	0	3	3	2	50*	00	50
BIO 314	Cell Biology & Genetics	4	0	0	4	4	50	50	100
BIO 364	Cell Biology & Genetics (Prac.)	0	0	2	2	1	50*	00	50
MATHS-302	Linear Algebra and Operations Research	4	1	0	5	4	50	50	100
HSS 301	Elective I*	3	0	0	3	3	50	50	100
	Total	**23**	**1**	**8**	**32**	**28**	**450**	**300**	**750**

* Cumulative marks for mid semester and end semester evaluation.

Elective I*

Choose any one from the following:
• HSS-301a Economics
• HSS-301b Introduction to Psychology
• HSS-301c Sociology

SCHEME OF EXAMINATION OF B.E. BIOTECHNOLOGY

Second Year - Fourth Semester

Sub Code	Subject	Scheme of Teaching					Scheme of Examination		
							Theory/ Practical		
		L	T	P	Hrs	Credits	Sess.	Univ. Exam.	Total
BIO 411	Molecular Biology	4	0	0	4	4	50	50	100
BIO 461	Molecular Biology (Prac.)	0	0	2	2	1	50*	00	50
BIO 412	Thermodynamics	4	0	0	4	4	50	50	100
BIO 413	Chemical Reaction Engineering	4	0	0	4	4	50	50	100
BIO 463	Chemical Reaction Engineering (Prac.)	0	0	2	2	1	50*	00	50
BIO 414	Industrial Biotechnology	4	0	0	4	4	50	50	100
BIO 464	Industrial Biotechnology (Prac.)	0	0	2	2	1	50*	00	50
BIO 415	Immunology & Immuno-technology	4	0	0	4	4	50	50	100
BIO 465	Immunology & Immuno-technology (Prac.)	0	0	2	2	1	50*	00	50
BIO 416	Educational Tour	-	-	-		Non Credit	00	00	00
	Total	**20**	**0**	**8**	**28**	**24**	**450**	**250**	**700**

* Cumulative marks for mid semester and end semester evaluation.

SCHEME OF EXAMINATION OF B.E. BIOTECHNOLOGY

Third Year – Fifth Semester

Sub Code	Subject	Scheme of Teaching					Scheme of Examination		
							Theory/ Practical		
		L	T	P	Hrs	Credits	Sessional Marks	Univ. Exam.	Total
BIO511	Enzyme Engineering & Technology	4	0	0	4	4	50	50	100
BIO561	Enzyme Engineering & Technology (Prac.)	0	0	2	2	1	50*	00	50
BIO512	Bio-Process Engineering	4	0	0	4	4	50	50	100
BIO562	Bio-Process Engineering (Prac.)	0	0	2	2	1	50*	00	50
BIO513	Animal Cell Culture & Biotechnology	4	0	0	4	4	50	50	100
BIO563	Animal Cell Culture & Biotechnology (Prac.)	0	0	2	2	1	50*	00	50
BIO514	Transport Phenomena	4	0	0	4	4	50	50	100
BIO564	Transport Phenomena (Prac.)	0	0	2	2	1	50*	00	50
BIO515	Bioinstrumentation	4	0	0	4	4	50	50	100
BIO516	Training of 4- 6 weeks after 4th semester exams					1	50		50
	Total	**20**	**-**	**08**	**28**	**25**	**500**	**250**	**750**

* Cumulative marks for mid semester and end semester evaluation.

SCHEME OF EXAMINATION OF B.E. BIOTECHNOLOGY

Third Year - Sixth Semester

Sub Code	Subject	Scheme of Teaching					Scheme of Examination Theory/ Practical		
		L	T	P	Hrs	Credits	Sess.	Univ. Exam.	Total
BIO611	Recombinant DNA Technology	4	0	0	4	4	50	50	100
BIO661	Recombinant DNA Technology (Prac.)	0	0	2	2	1	50*	00	50
BIO612	Bio-Informatics	4	0	0	4	4	50	50	100
BIO662	Bio-Informatics (Prac.)	0	0	2	2	1	50*	00	50
BIO613	Bioreactor Design and Operation	4	0	0	4	4	50	50	100
BIO614	Down Stream Processing	4	0	0	4	4	50	50	100
BIO664	Down Stream Processing (Prac.)	0	0	2	2	1	50*	00	50
BIO615	Open Elective (Biomaterials)	4	0	0	4	4	50	50	100
	Total	**20**	**0**	**6**	**26**	**23**	**400**	**250**	**650**

* Cumulative marks for mid semester and end semester evaluation.

SCHEME OF EXAMINATION FOR B.E. BIOTECHNOLOGY

Fourth Year - Seventh Semester

Sub Code	Subject	Scheme of Teaching					Scheme of Examination Theory/ Practical		
		L	T	P	Hrs	Credits	Sessional Marks	Univ. Exam.	Total
BIO701	Environmental Biotechnology	4	0	0	4	4	50	50	100
BIO751	Environmental Biotechnology (Prac.)	0	0	2	2	1	50*	00	50
BIO702	Food Biotechnology	4	0	0	4	4	50	50	100
BIO752	Food Biotechnology (Prac.)	0	0	2	2	1	50*	00	50
BIO703	Plant Tissue Culture	4	0	0	4	4	50	50	100
BIO704	Bio-analytical Techniques	4	0	0	4	4	50	50	100
BIO754	Bio-analytical Techniques (Prac.)	0	0	2	2	1	50*	00	50
BIO705	Minor Project (Prac.)	0	0	4	4	2	50*	00	50
BIO706	Training of 4- 6 weeks after 6^{th} semester examinations					1	50	00	50
	Total	**16**	**0**	**10**	**26**	**22**	**450**	**200**	**650**

* Cumulative marks for mid semester and end semester evaluation.

SCHEME OF EXAMINATION FOR B.E. BIOTECHNOLOGY

Fourth Year - Eight Semester

Option 1	Sub Code	Subject	Scheme of Teaching					Scheme of Examination		
								Theory/ Practical		
			L	T	P	Hrs	Credits	Sessional Marks	Univ. Exam.	Total
	BIO801	Major Project (Prac.)	0	0	4	4	2	50*	00	50
	BIO802	Enzyme catalyzed Organic Synthesis	4	0	0	4	4	50	50	100
	BIO852	Enzyme catalyzed Organic Synthesis (Prac.)	0	0	3	3	2	50*	00	50
	BIO803	Project Management and Entrepreneurship	4	0	0	4	4	50	50	100
	BIO804	Modeling and Simulation of Bioprocesses	4	0	0	4	4	50	50	100
	BIO854	Modeling and Simulation of Bioprocesses (Prac.)	0	0	3	3	2	50*	00	50
	BIO805	Elective-I*	4	0	0	4	4	50	50	100
		Total	**16**	**0**	**10**	**26**	**22**	**350**	**200**	**550**
Option 2	BIO806	Industrial Training	**---**	**---**	---	**---**	**22**	**350**	**200**	**550**
		Total	**---**	**---**	**---**	**---**	**22**	**350**	**200**	**550**

* Cumulative marks for mid semester and end semester evaluation.

Options in Elective - I*

1. Nanobiotechnology

2. Microbial Biodiversity

Conditions for choosing Option 2 in 8th Semester:

A student may opt for either Option 1 or one semester training (Option 2) in lieu of subjects of 8th Semester (option 1). The marks for six months training will be equal to the total marks of 8th Semester study. A student can opt for six semester training under following conditions:

a. The student got selected for job in campus placement and the employer is willing to take that student for the training.

b. The student got offer of pursuing training from reputed government research organization/govt. sponsored projects/govt. research institution provided that student should not be paying any money to get trained. For pursuing this training student needs the prior approval from the Coordinator of the respective branch.

SYLLABUS
B.E. BIOTECHNOLOGY
THIRD SEMESTER

Course Code	BIO 311
Course Title	Process Calculations
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Fundamental course in physics, chemistry and mathematics.
Course Objectives (CO)	1. To develop a fundamental understanding of the basic principles of process calculations. 2. To introduce students to calculations involving material and energy balance for reaction and separation processes. 3. To learn about the PVT relations and gaseous mixtures. 4. To introduce students to the use of data sources for physical and chemical properties and the estimation of such data.
Course Outcome	1. Define and determine properties of process streams. 2. Analyze and solve elementary material balances on single and multiple unit processes with recycle and bypass for reactive and non-reactive processes. 3. Solve energy balance on reactive and non-reactive processes. 4. Use psychrometric charts and steam tables for estimating physical and thermodynamic properties of gas-vapour mixtures.

SYLLABUS

Note: *The question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having*

questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.

SECTION-A

Introduction to Engineering Calculations: Units and dimensions, mole concept, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equations and stoichiometry. Composition of mixtures and solutions: mass fractions, mole fraction. (10)

Material Balance: Material balance with and without chemical reactions; Material balance involving multiple subsystems; recycle, bypass and purge. Concept of limiting and excess reactant, conversion and yield. Metabolic stoichiometry of growth and product formation. (15)

SECTION-B

P-V-T relations for gas and gas mixtures, calculations using ideal gas law, vander waal's equation of state. Liquid and liquid mixtures, vapor pressure, saturation, partial saturation and humidity. (10)

Enthalpy changes, energy balance for simple flow process, calculation of heat capacity, mean heat capacity, application of the energy balance to systems with and without reactions. Use of Hess's law for calculation of heats of formation, heats of combustion, heats of reaction. Kirchoff's equation for calculating heats of reaction at different temperatures. (10)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1.	Elementary Principles of Chemical Processes	R.M.Felder, R.W.Rousseau	John Wiley & Sons 3rd Edition 2011.
2.	Basic Principles and Calculations in Chemical Engineering	D.M.Himmelblau, D.M.Riggs	PHI Learning Private Limited 8th Edition 2012
3.	Stoichiometry	B.I.Bhatt, S.M.Vora	Tata McGraw Hill 4th Edition 2006
4.	Bioprocess Engineering- Basic Concepts	M.L.Shuler, F.Kargi	Prentice Hall 2nd Edition 2007

Course Code	BIO312
Course Title	Microbiology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of the prokaryotic and eukaryotic cell structure and the nature and function of different bio-molecules
Course Objectives (CO)	1. To familiarize the students with the discipline of Microbiology, historical developments and various extensions of Microbiology 2. To make students understand the different structural and functional aspects of microorganisms 3. To teach students about different methods and approaches of microbial classification and techniques of working with microorganisms 4. To explain to students the role of microorganisms in different scenarios
Course Outcome	1. The students are able to identify the development, importance and scope of Microbiology as a discipline. 2. The students are able to explain the structure, function and diversity of different microorganisms 3. The students are empowered to handle and maintain microbial cultures and explain the grouping of microorganisms 4. The students can identify different microbial interactions at various levels and explain the role and scope of microorganisms for greater use

SYLLABUS

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will be divided into two parts having three questions each and the candidate is required to attempt at least two questions from each section.

SECTION-A

Brief history of microbiology. Scope and application of microbiology to biotechnology (in agriculture, food, health, environment, industry) (3)

Microbial diversity- Fine structure of bacteria, fungi, algae, virus (8)

Methods in microbiology- cultural characteristics and cultivation of microorganisms, pure culture technique, enumeration and preservation of microorganisms, principles of microbial nutrition, construction of culture media, theory and practice of sterilization, control of microorganisms by physical, chemical and biological agents, methods of bacterial staining (simple, differential and special stains) (9)

Microbial growth - definition, expression, measurement, Growth curve, synchronous and asynchronous growth. Transport of nutrients across the cell membrane (4)

SECTION-B

Microbial metabolism- Energy generation and biosynthesis in prokaryotes (6)

Microbial genetics- Mutations, recombination in bacteria, conjugation, transduction, transformation (5)

Microbial classification and phylogeny– characterization, classification and identification of bacteria including molecular approaches. An introduction to Bergey's Manual and different groups of bacteria (6)

Microbes as geochemical agents- nitrogen, phosphorous, carbon and sulphur cycles; microbial interactions (4)

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1.	Microbiology	Pelczar Jr., M.J., Chan, E.C.S. and Krieg, N. R.	Tata McGraw Hill (2003) 5th ed.
2.	General Microbiology	Stainer, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R.	MacMillan (2007) 5th ed.
3.	Microbiology- An Introduction	Tortora, G.J., Funke, B.R., and Case, C.L.	Benjamin Cummings (2009)10th ed.
4.	Brock Biology of Microorganisms	Madigan, M.T., Martinko, J.M., Stahl, D.A. and Clark, D.P.	Benjamin Cummings (2010) 13th ed.
5.	Prescott, Harley and Klein's Microbiology	Willey, J.M., Sherwood, L.M. and Woolverton, C.J.	McGraw Hill Higher Education, (2008) 7th ed.

Course Code	BIO 362
Course Title	Microbiology (Practical)
Type of Course	Core
L T P	0 0 3
Credits	2
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Microbiology (Theory)
Course Objectives (CO)	1. To impart to students skills to work with microorganisms and familiarize them with different techniques used in a microbiology lab
Course Outcome	1. **S**tudents are able to isolate, grow, identify and maintain different microbial cultures 2. Students become proficient to use microbial techniques in different scenarios pertaining to biotechnology

SYLLABUS

List of Experiments:

1. To prepare different culture media-broth and agar
2. To learn the culturing of microorganisms by simple streaking and pure culture technique
3. To learn the preservation of microorganisms on agar slants
4. To isolate microorganisms from soil/ milk/food sample by dilution plate method.
5. To study the working of a compound microscope
6. To perform Gram staining of a given microbial sample
7. To perform endospore staining of endospore forming microorganisms
8. To perform motility test on the given bacterial sample

Course	BIO 313
Course Title	Biochemistry (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of cell structure and functions of different cell types, organ system. Knowledge of mammalian, plant and microbial systems in Biotechnology
Course Objectives (CO)	1. To study the structures and functions of various biomolecules like carbohydrates, lipids, nucleic acids, proteins and vitamins in biosystem 2. To understand the structure-function relationship in proteins, purification and sequencing of proteins/enzymes. 3. To study the anabolic and catabolic pathways of carbohydrates and fats and its significance. 4. To understand the biochemical pathways of nucleic acid biosynthesis and degradation. 5. To study the biochemical pathways of photosynthesis and nitrogen fixation in plants and microbes respectively.
Course Outcome	1. Students learn the basic concepts of biochemistry such as structural and functional aspects of biomolecules, necessary for biotechnology studies and applications. 2. Students understand how biomolecules function as a unit to build a complex multicellular organism, undergoing diverse functions and cellular metabolic pathways in mammals, plants and microorganisms. 3. Students learn the role of enzymes and other molecules in metabolic pathways and how regulation of biochemical pathways is attained in a cell. 4. To understand the biochemical pathways in plants and organisms.

SYLLABUS

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SECTION-A

Structure, function and biological role of following Biomolecules:

a) amino acids b) proteins c) carbohydrates d) lipids
e) nucleic acids f) water soluble vitamins (15)

Proteins: Primary, secondary, tertiary and quaternary structures, methods for isolation and purification of proteins and enzymes, amino acid sequence determination (4)

Carbohydrate metabolism: Glycolysis, glycogenolysis, glycogenesis and their regulation, citric acid cycle. (5)

SECTION-B

Fat metabolism: Oxidation of fatty acids, synthesis of fatty acids (fatty acid synthase complex), ketone bodies. (5)

Amino acid metabolism: General reactions of amino acid metabolism such as transamination, decarboxylation , deamination . Urea cycle. (4)

Nucleic acid metabolism: Biosynthesis of purines and pyrimidine nucleotides, biosynthesis of deoxyribonucleotides, their regulation, catabolism. (5)

Mitrochondria: Structure of mitochondria, organization of respiratory chain, oxidative phosphorylation (3)

Plant and microbial biochemistry- Photosynthesis and Nitrogen fixation (4)

RECOMMENDED BOOKS

S. No	NAME	AUTHOR(S)	PUBLISHER
1	Lehninger's Principles of Biochemistry	Nelson, DL and Cox, M. M	Worth Publishers, New York, 5th ed, 2010
2	Harper's Biochemistry	Murray, R.K, Bender DA et al	Mc Graw Hill, America,28th ed, 2008
3	Biochemistry	Voet D and Voet JG	John Wiley and Sons, Inc. New York, 4th ed, 2010
4	Biochemistry	Stryer, Lubert	W.H Freeman and Company, New York, 6th ed, 2006
5	Biochemistry: clinical correlations	Zubay, GL	W.H. Freeman and Company New York, 4th ed, 2002
6	Outlines of biochemistry	Conn, E.C. and Stumph, P.K	John Wiley & Sons,5th edition, 2006

Course Code	BIO 363
Course Title	Biochemistry (Practical)
Type of Course	Core
L T P	0 0 3
Credits	2
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Understanding of biomolecules and biochemistry.
Course Objectives (CO)	1. To give practical training of the analysis of various biochemical parameters having clinical and industrial relevance. 2. To have an understanding of the principle of each determination by biochemical reactions using UV –visible spectroscopy. 3. To resolve biomolecules by chromatographic technique.
Course Outcome	1. Students have hands on training of quantitations related to biomolecules in biochemistry. 2. Students learn quality control in clinical biochemistry by performing blood analysis.

SYLLABUS

List of Experiments:

1. To study Beer-Lambert Law and to determine λ max of a colored dye.
2. To estimate carbohydrate content in a given sample by Anthrone method.
3. To determine total amount of proteins in serum by Biuret method.
4. To estimate proteins by Lowry method.
5. To identify the amino acids in a mixture by ascending paper chromatography.
6. To determine the content of nucleic acids by UV method.
7. To quantitate RNA/DNA in the given sample by colorimetric method.
8. To determine cholesterol/ urea/uric acid in blood.

Course Code	BIO 314
Course Title	Cell Biology and Genetics (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Students should be familiar with basic concepts and theories related to DNA molecule.
Course Objectives (CO)	1. Students will be able to define structure of plasma membrane, cytoskeletal elements, ECM and chromosome. 2. Students will be able to describe cell cycle, its regulation and their importance. 3. Students will be able to state and explain the concept of genetics and Mendelian principles. 4. Students will be able to describe the chromosome theory of inheritance, extra chromosomal inheritance and cytogenetics.
Course Outcome	1. The students are able to define structure of plasma membrane, cytoskeletal elements, ECM and chromosome. 2. The students are able to describe cell cycle, its regulation and their importance. 3. The students are able to state and explain the concept of genetics and Mendelian principles. 4. The students are able to describe the chromosome theory of inheritance, extra chromosomal inheritance and cytogenetics.

SYLLABUS

Note: *The question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.*

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SECTION-A

Biological membranes: models, structure and function, membrane proteins (6)
Cytoskeletal elements: microtubules, intermediate filaments and microfilaments, their structure and functions (3)
Extracellular matrix interactions: Types of ECM, interaction of cell with the ECM, malfunctions in ECM signaling (3)
Chromosomes structure and organization: Chemical composition of DNA, structural organization of nucleosomes, chromosomal organization, polytene and lampbrush chrosmosomes, human chrosmosomes, centrosome, telomere (4)
Types of DNA sequence: unique and repetitive DNA, hetero chromatin (1)
Cell cycle: Phases in cell cycle, regulation and control of cell cycle (2)
Cell division: Detail of different stages in Mitosis and meiosis, their importance (3)

SECTION-B

Molecular genetics: C value paradox, cot curve, repetitive sequences, transposons (bacterial, eukaryotic, retrotransposons, viral), gene families, homologus gene, pseudogene (4)
Extensions of Mendelian principles : Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, (5)
Chromosome Theory of Inheritance The chromosome theory of heredity, Sex Chromosomes and sex determination, Genetic linkage and Genetic mapping, sex linkage, sex limited and sex influenced characters**.** (7)
Extra chromosomal inheritance : Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. (2)
Cytogenetics: Human Karyotype, chromosome banding, ploidy, chromosome aberrations (5)

RECOMMENDED BOOKS

S. No.	Name of Book	Author(S)	Publisher
1	Lehninger Principles of Biochemistry	David L. Nelson and Michael M. Cox	W. H. Freeman & Company Fourth Edition
2	Molecular Cell Biology	Lodish HF, Baltimore D, Berk A, Zipursky L, P. Matsudaira P, and Darnell JE	Wiley & Sons (2003) 4th edition
3	Molecular Biology of the Cell	Albert B, Johnson A, Lewis J, Raff M, Roberts K, Walter P	Garland Science, Taylor and Francis group (2008) 5th edition
4	The Cell: A Molecular Approach	Cooper GM, Hausman RE,	ASM Press (2007) 4th edition

5	Cell and Molecular Biology: Concepts and Experiments	Karp G	John Wiley & Sons, 6th edition
6	Principles of Genetics	Gardner EJ, Simmons MJ, Snustad DP	John Wiley & Sons (1991) 8th edition
7	Genetics: Analysis of Genes and Genomes	Hartl DL& Jones EW	Jones and Bartlett Publication, (2008) 6th edition
8	Genetics	Strickberger	Prentice Hall, (2002) 3rd edition
9	Genetics	Weaver P and Hedrick R	McGraw Hill Publishers, (2002) 3rd edition

Course Code	BIO 364
Course Title	Cell Biology and Genetics (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Cell Biology and Genetics (Theory)
Course Objectives (CO)	1. Students will be able to analyze cell structure and its components through microscope 2. Students will be able to employ methods for determining bacterial cell density and viabilty.
Course Outcome	1. Students are able to analyze cell structure and its components through microscope 2. Students are able to employ methods for determining bacterial cell density and viabilty

SYLLABUS

List of Experiments:

1. To study structure of cell from onion leaf peels.
2. Extraction of collagen ECM using glacial acetic acid.
3. Determination of bacterial cell optical density by counting of bacterial cells using hemocytometer.
4. Determination of cell no. (viable/nonviable) in bacterial cell population.
5. Chromosomal preparation of mitotic cell division using onion root tip and observation under simple microscope.
6. Staining of DNA and RNA using methyl green and pyronin stains.
7. Observation of cell cycle and cell division related permanent slides.

Paper Title : Linear Algebra and Operations Research

Paper Code : MATHS-302

LTP : 4 1 0

Pre Requisite : MATHS-101

Max (Univ. Exam) Marks : 50 **Time of examination: 3hrs.**

Internal Assessment : 50

Course Duration: 45 lectures of one hour each.

Course Objectives:

1. Definitions and learning various concepts related to vector space, basis and system of equations, eigen values and vectors and diagonalization of matrices.
2. To learn modeling of practical problem in the form of linear programming problems and explain various concepts of optimization theory and duality theory.
3. To learn various methods for the solutions of transportation problem, assignment problem, CPM and PERT.

Note for the examiner: The semester question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having questions of conceptual nature, will be compulsory. Rest of the paper will be divided into two parts having three questions each and the candidate is required to attempt two questions from each section.

S. No.	Topic	No. of Lectures
	PART A	
1.	**Linear Algebra:** Concept of linear independence and dependence, Rank of a matrix: Row – Echelon form, Vector space, Dimension, Basis, System of linear equations: Condition for consistency of system of linear equations, Solution by Gauss elimination method. Inverse of a matrix: Gauss – Jordan elimination method. (Scope as in Chapter 6, Sections 6.3 – 6.5, 6.7 of Reference 1).	**7**
2.	Eigen values, eigen vectors, Cayley – Hamilton theorem (statement only). Similarity of matrices, Basis of eigenvectors, diagonalization (Scope as in Chapter 7, Sections 7.1, 7.5 of Reference 1).	**7**

3.	**Optimization Problems. Linear Programming:** Graphical Method (Scope as in Chapter 1 of Reference 4). Solution of simultaneous linear equations: An overview (Scope as in Chapter 2, Sections 2.15 – 2.16 of Reference 4). Basic solutions, lines and hyperplanes, convex sets, extreme points, convex sets and hyperplanes (Scope as in Chapter 2, Sections 2.19 – 2.21 of Reference 4). Reduction of any feasible solution to a system of equations to a basic feasible solution. Simplex Method: The simplex algorithm (Scope as in Chapter 3, 4 of Reference 4). Tableau format for simplex computations, Charne's M-method, Two phase method (Scope as in Chapter 5 of Reference 4).	**11**
	PART B	
4.	**Duality theory:** Formulation of the dual problem, Theorems on duality: Weak Duality Theorem, Strong Duality Theorem, Complementary Slackness Theorem, Dual Simplex Algorithm (Scope as in Chapter 8, Sections 8.1 – 8.12 of Reference 4).	**7**
5.	**Transportation Problem:** Initial solution by North-West corner rule, Row minima method, Column minima method, Matrix minima method, Vogel's method. Tableau of transportation problem, u-v algorithm for solving transportation problem. Degeneracy in transportation problem. (Scope as in Chapter 9 of Reference 4).	**7**
6.	**The Assignment Problem:** Hungarian Method (Scope as in Chapter 5, Section 5.4 of Reference 4).	**3**
7.	**CPM and PERT:** Network representation, Critical path computations, Construction of time schedule, Linear programming formulation of CPM, PERT networks (Scope as in Chapter 6, Section 6.6 of Reference 5).	**3**

Course outcomes:

1. Students will be able to understand various concepts of linear algebra, solution techniques for system of linear equations and implementation of these techniques for solution of various practical problems.
2. Students will be able to construct the mathematical model of any system involving linear constraints and examine its optimal solution.
3. Using duality , students will be able to interpret the economical structure of the optimization problem.
4. Students will be able to learn the importance of transportation and assignment problems in real life and will be able to choose the best possible solution of the combinatorial problem.
5. Students will be able to predict and analyze the progress of the project using CPM and PERT.

References:

1. E. Kreyszig. Advanced Engineering Mathematics, Eighth Edition, John Wiley.
2. Michael D. Greenberg. Advanced Engineering Mathematics, Second Edition, Pearson Education.
3. Vivek Sahai, Vikas Bist. Linear Algebra, Narosa Publishing House, New Delhi, 2002.
4. G. Hadley. Linear Programming, Narosa Publishing House, New Delhi, 2002.
5. Hamdy A. Taha. Operations Research, An Introduction, Seventh Edition, Pearson Education, Delhi, 2003.
6. Kanti Swaroop, P. K. Gupta, Man Mohan. Operations Research, Twelfth Edition, Sultan Chand and Sons, New Delhi, 2004.
7. A. M. Natarajan, P. Balasubramani, A. Tamilarasi. Operations Research, Pearson Education, Delhi, 2005.

SYLLABUS
B.E. BIOTECHNOLOGY
FOURTH SEMESTER

Course Code	BIO 411
Course Title	Molecular Biology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Students should have prior knowledge of structure and functions of basic biomolecules such as DNA, RNA and proteins.
Course Objectives (CO)	1. Students will be able to describe DNA and RNA metabolism**.** 2.Students will be able to explain protein metabolism and its importance . 3. Students will be able understand about signal transduction process and its function. 4. Students will be able to explain various molecular techniques and their application in medicine.
Course Outcome	1. Students are able to explain DNA and RNA metabolism**.** 2. Students are able to explain protein metabolism and analyze its importance 3. Students are able to discuss about signal transduction process and its function. 4. Students are able to analyze various molecular techniques and their application in medicine.

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SYLLABUS

Note: *The question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.*

SECTION-A

Introduction-Chromosome, chromatin, gene for understanding molecular processes (1)

DNA replication-Unit of replication, enzymes involved, replication process (initiation, elongation and termination) in Prokaryotes and Eukaryotes, fidelity of replication, extrachromosomal replicons (6)

DNA repair and recombination mechanism-Importance of DNA repair and recombination, various types of DNA damages and repair mechanisms in Prokaryotes and Eukaryotes, homologous and site-specific recombination, DNA transposition (6)

RNA metabolism in eukaryotes and prokaryotes – structure, function and types of RNA, Transcription factors and machinery, formation of transcriptional initiation complex, elongation and termination (6)

Post transcriptional modifications- splicing, capping and polyadenylation, RNA editing . (3)

Genetic Code Characteristics of genetic code, degenracy of codon & Wobble Hypothesis (2)

SECTION-B

Protein metabolism in eukaryotes and prokaryotes-small and large Ribosomal subunits in eukaryotes and prokaryotes, various translational factors, translation initiation, (aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading), elongation and termination, translational inhibitors, Post-translational modifications (7)

Regulation of gene expression-Operons in prokaryotes (lac and galactose operons), Regulatory elements in eukaryotes (enhancers, activators, mediators), Control of gene expression at translation level (such as si-RNA), regulation through epigenetic mechanism. (6)

Signal Transduction- Cell surface receptor, second messenger molecules, signaling through G-protein coupled receptors, signal transduction pathways, bacterial chemotaxis and quorum sensing (4)

Basic Molecular biology Techniques and their applications- Principle, general and specialized electrophoretic techniques, gel electrophoresis (types of gels, modes of gel electrophoresis) Distcontinuous gel electrophoresis, isoelectric focusing, 2D gel electrophoresis, pulse field gel electophoresis, PCR, molecular hybridization and their applications (3)

Role of molecular biology in molecular medicine (1)

RECOMMENDED BOOKS

S. No.	Authors	Title	Publisher and Edition
1	David L. Nelson and Michael M. Cox	Lehninger Principles of Biochemistry	W. H. Freeman & Company Fourth Edition
2	Latchman, D.,	Basic Molecular and Cell	Black Well pub

		Biology, 2006	3rd edition
3	Lewin, B.	Gene VIII, 2003	Oxford University Press, New York.
4	Stansfield, W. D., Colome, J.S. and Cano, R. J.	Schaum's Outline of Theory and Problems of Molecular and Cell Biology, 2004	Tata McGraw Hill
5	Glick, B.R. and Pasternak, J. J.	Molecular Biotechnology, Principles and applications of recombinant DNA (2004)	American Society for Microbiology Press, Washington D.C. Second edition,

Course Code	BIO 461
Course Title	Molecular Biology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Molecular Biology (Theory)
Course Objectives (CO)	1. Students will be able to understand the basic techniques used for isolation of RNA, DNA and protein 2. Students will be able to understand methods of transformation and selection of clones in recombinant DNA technology
Course Outcome	1. Students are able to learn the basic techniques used for isolation of RNA, DNA and protein 2. Students are able to learn the technique of clones selection used during recombinant DNA technology

SYLLABUS

List of Experiments

1. Genomic DNA extraction from yeast cells using mechanical disruption and resolution of DNA on agarose gel.
2. Total RNA extraction from yeast cells.
3. Resolution of isolated RNA on formaldehyde agarose gel.
4. To study cell cycle arrest in onion root tip cells by treatment with colchicines.
5. Study of bacterial lac operon regulation in bacterial cells using IPTG as an inducer molecule.
6. Generation of auxotrophic markers in yeast using UV induced mutagenesis method.
7. Extraction of total proteins from bacterial cells/animal cell and its separation using one-dimensional SDS gel electrophoresis method

Course Code	BIO 412
Course Title	Thermodynamics (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Process Calculations, Physical Chemistry, Mathematics and Biochemistry
Course Objectives (CO)	1. To learn the fundamentals of thermodynamics, understand various forms of energy including heat and work. 2. Application of laws of thermodynamics. 3. Study different refrigeration cycles 4. Understand the criteria of phase equilibrium for a pure substance and mixtures 5. Understanding of the quantitative aspects of chemical reaction equilibrium
Course Outcome	**1**. Calculate changes in enthalpy, internal energy and entropy for ideal gases. 2. Calculate heat and work requirements for different processes 3. Predict the vapor –liquid equilibrium compositions for a binary system.. 4. Calculate the composition at equilibrium for single reactions in a single phase as a function of temperature and pressure.

SYLLABUS

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SECTION-A

Review: state functions**,** types of systems, internal energy, heat and work, reversible and irreversible processes, first laws of thermodynamics and its application, Heat capacities, Heat effects during phase change, reaction, formation, combustion and mixing. (8)

Throttling process, Joule Thompson coefficient, liquefication of gases. (4)

Second law of thermodynamics, concept of entropy, Refrigeration cycle, refrigerants, vapor compression cycle, Absorption refrigeration, Third Law of thermodynamics. (7)

SECTION-B

Vapor liquid equilibrium: Duhem's theorem, Raoult's law, Henry's law. Estimation of vapor liquid equilibrium data. Solution thermodynamics: chemical potential, phase equilibria, partial properties, Gibbs/Duhem equation. Concept of fugacity and fugacity coefficient, activity and activity coefficient. (12)

Chemical Equilibrium: chemical reaction equilibrium; standard free energy change and equilibrium constant, effects of temperature on free energy change; equilibrium constant; equilibrium conversion. (10)

Applications of thermodynamics to bio-systems. (4)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1.	Introduction to Chemical Engineering Thermodynamics	J.M.Smith, H.C.VanNess and M. Abbott	Tata McGraw-Hill.
2.	Chemical Engineering Thermodynamics	Y.V.C.Rao	University Press
3.	Introductory Chemical Engineering Thermodynamics	J.R.Elliott and C.T. Lira	Prentice Hall

Course Code	BIO 413
Course Title	Chemical Reaction Engineering (Theory)
Type of Course	Core
L T P	400
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of material balance equation and mathematical equations.
Course Objectives (CO)	1. To understand the characteristics of kinetics of chemical reactions. 2. To study different types of ideal reactors. 3. To gain understanding of single and multiple reactions. 4. To follow various aspects of biochemical kinetics.
Course Outcome	1. Understanding of the data analysis. 2. To implement various types of reactor configuration at appropriate conditions. 3. Knowledge of design of single and multiple reactions and their product distribution. 4. Understanding of various components of microbial and enzymatic fermentations

SYLLABUS

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SECTION-A

Kinetics: Types of reactions, Rate Equation, Analysis of Mechanism and Rate equations for archetypal models of reactions, Intermediates, Data Analysis. (8)

Ideal Reactors: Batch, Plug Flow Reactor, CSTR (Constant Volume & Variable Volume). (6)

Multiple Reactor system for Single Reactions (5)

Biochemical reaction systems: Michaelis-Menten kinetics, Kinetic of competitive and Non-competitive inhibition, evaluation of M-M equation parameters, enzyme fermentation in batch, plug-flow and mixed flow fermenters. (4)

SECTION-B

Thermal Characteristic of Reactors: Optimum temperature progression, Adiabatic Operations. (6)

Design for Multiple Reactions: Qualitative and Quantitative Product distribution for Parallel and Series reaction. Qualitative product distribution of Series-Parallel reactions. (10)

Biochemical kinetics: Microbial Fermentation, Monod Growth Model, qualitative treatment in Batch and Mixed-flow fermenter, Kinetics of availability of food and harmful wastes. (6)

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1.	Chemical Reaction Engineering	Levenspiel,O	(John Wiley & Son), 3rd edition, 1998.
2.	Elements of Chemical Reaction Engineering	Foggler, H. S.	(PHI), 4th edition, 2006.
3.	Chemical Engineering Kinetics	Smith, J.M.	(Mc-Graw Hill) than 3rd Ed. digitized in 2007.
4.	Biochemical Engineering Fundamentals	Bailey J. & Ollis E.	McGraw Hill Chemical Engineering Series.

Course Code	BIO463
Course Title	Chemical Reaction Engineering (Practical)
Type of Course	Core
L T P	002
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of concepts of chemical reaction engineering theory.
Course Objectives (CO)	1. To provide students with hands on training of different types of chemical reactors. 2. To compare performances of different reactors under different conditions.
Course Outcome	1. Students learn to operate different types of reactors. 2. Students learn to analyze data generated as a result of various reactor operations.

SYLLABUS

List of Experiments:

1. Kinetics studies for a non-catalytic reaction in a shake-flask using Integral method.
2. Kinetic studies in a batch reactor at a) constant temperature b) different temperatures.
3. Kinetic studies in a plug flow reactor.
4. Kinetic studies in a CSTR at a) constant temperature b) different temperatures.
5. RTD studies in CSTR.
6. Dispersion number for packed bed reactor.
7. Kinetic studies in a semi-batch reactor.

Course Code	BIO 414
Course Title	Industrial Biotechnology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Students should have done basic courses in Microbiology and Biochemistry
Course Objectives (CO)	1.To make the students understand the role of diverse organisms in industrial productions, their growth requirements and culture preservation. 2. To learn the methods applied for strain development. 3. To understand the microbial production process for of a wide range of products having varied applications. 4. To learn the stabilization methods of industrial enzymes, immobilization of enzymes and their role in biotransformations.
Course Outcome	1. The students will get knowledge of the role of large number of organisms in processes for microbial productions. 2. Students will learn the strain development and culture preservation techniques applied in industry. 3. Students will understand the intricacies of the production process for each class of compounds and the applications of a range of products. 4. Knowledge of enzyme applications, stability and immobilization methods required in industry.

SYLLABUS

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SECTION-A

Industrially important microbes (E. coli, Bacillus, Actinomyces, Saccharomyces) (4)
Preparation of an ideal growth medium for production of biomass and a microbial product, synthetic and crude media, prerequisites for preparation of a media. (4)
Strain improvement by genetic means (5)
Culture preservation (2)
Classifications of microbia1 products (2)
Microbial fermentations, Introduction to design of fermenters (5)

SECTION-B

Microbial production processes and applications of the following industrially important classes of products

a) Organic acids and solvents: citric acid, lactic acid, acetone and butanol (4)
b) Antibiotics: Classification and production of penicillin, streptomycin (4)
c) Enzymes: Amylases, proteases (3)
d) Flavoring agents : nucleosides and nucleotides. (2)
e) Other upcoming productions such as dextran and carotene. (4)

Microbial enzymes and enzyme immobilization methods. (4)
Microbial biotransformations and role of enzymes in bio-conversions of industrially important compounds. (2)

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1	Industrial Microbiology	L.E. Casida	John Wiley & Sons
2	Biotechnology –A Text Book Of Industrial Microbiology	Crueger W and Crueger A	Sinauer, 1990
3	Industrial Microbiology	M.J. Waites et al	Blackwell Science Ltd. London 2002

Course Code	BIO 464
Course Title	Industrial Biotechnology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Experience of handling microbial cultures and biochemical analysis.
Course Objectives (CO)	1.To have practical training of the concepts and topics done in theory. 2. To get practical training in studying the growth curve and utilization of carbon source in media by bacterial/ yeast cultures. 3. To get practical training in media preparation, cell counting and product formation in bacteria/yeast.
Course Outcome	1.Practical Exposure in handling/ culturing of microorganisms, cell counting, measurement of product formation with respect to time of growth and by biochemical assay of product formation. 2. Practical Experience of identification and preservation of microbial cultures.

SYLLABUS

List of Experiments:

1. To identify bacteria on the basis of Gram's Staining.
2. To study the growth of E.coli / bacillus in broth media and plot the growth curve.
3. To determine the cell count of S. cerevisiae using Neubauer chamber.
4. To determine the concentration of glucose by DNSA reagent and plot the standard curve for glucose.
5. To study the utilization of glucose by S. cerevisiae/ Bacillus subtilis.
6. To plot a standard curve of ethanol by using dichromate oxidation method.
7. To study the production of ethanol during the growth of S. cerevisiae.
8. To identify industrially important fungi from slides.
9. To perform cryopreservation of bacteria/ yeast.

Course Code	BIO 415
Course Title	Immunology and Immunotechnology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Students should have prior basic knowledge of structure and functions of organs of human body.
Course Objectives (CO)	1. Students will be able to describe cells and tissues of immune system 2. Students will be able to explain basic of antigen and antibodies and their generation 3. Students will be able to illustrate importance of antigen processing, presentation and Major Histocompatiblity Complex in immunity. 4. Students will be able to explain in detail vaccines development.
Course Outcome	1. Students are able to explain cells and tissues of immune system. 2. Students are able to to explain basic of antigen and antibodies and their generation 3. Students are able to illustrate importance of antigen processing, presentation and Major Histocompatiblity Complex in immunity. 4. Students are able to explain in detail vaccines development.

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SYLLABUS

Note: *The question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.*

SECTION-A

Introduction- Introduction and historical perspectives of immune system. (2)

Cell and Tissues of immune system: Lymphoid cell, mononuclear cell, granulocytes, mast cells, dendritic cells, primary lymphoid organs, lymphatic system, secondary lymphoid organs. (4)

Antigens and Haptens: Immunogenecity, chemical composition, susceptibility (4)

to antigen processing, immunogen dosage and route of administration, haptens, adjuvants.

Antibody Structure, Function and Diversity: Basic structure, Immunoglobulin domains, classes. (6)

Major Histocompatiblity Complex: MHC molecules, cellular distribution, general importance. (3)

Antigen processing and Presentation to T cell: Antigen presenting cells and their role, pathway. (4)

SECTION-B

B and T cell activation: Antigen recognition and activation of immune response. (4)

Autoimmunity: Organ specific and systematic autoimmune diseases. (3)

Hypersensitive Reactions: Types, mechanisms of hypersensitivity. (3)

Complement System: Components, Complement activation, consequences. (4)

Antigen-antibody reactions: interaction, cross reactions, precipitation and agglutination. (1)

Vaccines: Active and Passive immunization, various types of vaccines (3)

Applications of antibodies : Polyclonal and monoclonal antibodies, Immunoassays, radioimmunoassay, Enzyme linked immunosorbent assay, Western blotting, Immunoctyochemistry, supershift assays (4)

RECOMMENDED BOOKS

S. No.	**Authors**	**Title**	**Publisher and Edition**
1.	Goldsby, R.A., Kindt, T.J., and Osborne, B. A.	Kuby Immunology (2000)	W.H. Freeman & Co., NY. 6th edition
2.	George, P.	Schaum's Outline of Theory and Problems of Immunology (2004)	Tata McGraw Hill Edition 1st edition,
3	Abbas, A. K., Lichtman, A. H. and Pober, J. S.	Cellular and Mol.Immunology, (2000)	Saunders Elsevier 6th edition
4	Riott, I.M.	Essential Immunology (2000)	ELBS/ Blackwell Scientific Publications, U.K 11th edition

Course Code	BIO 465
Course Title	Immunology and Immunotechnology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Immunology and Immunotechnology (Theory)
Course Objectives (CO)	1. Students will be able to demonstrate isolation, separation and quantification of various cells and biomolecules of immune system present in blood 2. Students will be able to illustrate various antigen and antibodies reactions
Course Outcome	1**.** Students are able to demonstrate isolation, separation and quantification of various cells and biomolecules of immune system present in blood 2. Students are able to illustrate the various antigen and antibodies reactions

SYLLABUS

List of Experiments

1. Separation of plasma and serum from given blood sample.
2. Determination of Total Leukocyte Count (TLC) of given blood sample.
3. Determination of Differential Leukocyte Count (DLC) of given blood sample.
4. Determination of blood group antigens by hemeagglutination assay for typing blood sample.
5. Estimation of antigen concentration in an unknown sample using simple radial immunodiffusion assay.
6. Estimation of antigen concentration in an unknown sample using Ouchterlony double diffusion assay.
7. Demonstration of ELISA for antigen diagnostics.

SYLLABUS
B.E. BIOTECHNOLOGY

FIFTH SEMESTER

Course Code	BIO 511
Course Title	Enzyme Engineering & Technology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Introductory biochemistry and general reaction kinetics
Course Objectives	1. To introduce the basic concepts and different types of enzyme 2. To make the student understand the mechanisms of enzymatic reaction. 3. To teach students about enzyme inhibitors and activators; effect of pH and temperature. 4. To understand about enzyme immobilization and its applications. 5. To understand about enzymatic reactors for batch/continuous and biochemical reaction in enzymatic reactors.
Course Outcome	1. Student will learn about basic concepts and kinetic reaction of enzyme. 2. Student will know about various methods of Immobilization and micro-environmental effect. 3. Student will know reactors for batch/continuous enzymatic processing, choice of reactor type; idealized enzyme reactor systems. 4. Student will solve steady state analysis of mass transfer and biochemical reaction in enzyme reactors bio-process design.

SYLLABUS

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questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.

SECTION-A

Introduction & Scope; General distinctive features and industrial applications. (4)

Enzyme kinetics; single, substrate steady state kinetics; King-Altman's method (8)

Inhibitors and activators; effect of pH and temperature. (7)

Multi-substrate systems and allosteric enzymes. (4)

SECTION-B

Immobilization of enzymes; advantages; carriers; adsorption; covalent coupling; cross linking and entrapment methods. (5)

Enzyme reactors; reactors for batch/continuous enzymatic processing, choice of reactor type; idealized enzyme reactor systems; mass transfer in enzyme reactors. (5)

Steady state analysis of mass transfer and biochemical reaction in enzyme reactors bio-process design. (7)

Physical parameters, reactor operational stability; operational strategies; a few case studies. (5)

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1	Biochemical Engineering Fundamentals	J.E. Bailey and P.F. Ollis	McGraw Hill (1986), 2nd ed.
2	Bioprocess Engineering Basic Concepts	P.H. M.L.Shuler, F.Kargi	Phi Learning Pvt Ltd (2002), 2nd ed.
3	*Enzymes:* Biochemistry, Biotechnology, Clinical Chemistry	T Palmer and P L Bonner	Horwood *Publishing* Ltd. (2007), 2nd ed.
4	Enzyme Kinetics: A Modern Approach	Alejandro g. Marangoni	John Wiley & Sons. (2003)

Course Code	BIO 561
Course Title	Enzyme Engineering & Technology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Enzyme Engineering & Technology (Theory)
Course Objectives (CO)	The course aims to provide the practical knowledge of enzymatic reactions.
Course Outcome	1. Student will know about enzyme kinetics. 2. Student will know procedure for enzyme immobilization

SYLLABUS

***List of Experiments*:**

1. To find out enzyme activity.
2. To study the effect of substrate concentration on enzyme.
3. To find out V_{max} and K_m of enzyme.
4. To study the effect of temperature on enzyme.
5. To study the effect of pH on enzyme.
6. To find out half life of enzyme.
7. To study the Enzyme immobilization by sodium alginate method and find out immobilized enzyme activity.

Course Code	BIO 512
Course Title	Bioprocess Engineering (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Chemical reaction engineering concepts and basics of microbiology.
Course Objectives (CO)	1. To summarize the characteristics of microbial growth in different processes 2. Description of sterilization of media and air. 3. To demonstrate the importance of aeration and agitation in fermentations. 4. Explaining scale up and scale-down concepts.
Course Outcome	1. Understanding of various components of microbial fermentation in different modes 2. Learning of design aspects of sterilizers 3. Learning of oxygen requirement and power requirement calculation for any fermentation process. 4. Understanding of scale-up approaches and their implementation.

SYLLABUS

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SECTION-A

Kinetics of microbial growth, substrate utilization and product formation in Batch, Fed-batch and continuous processes. (10)

Rheology of fermentation fluids and Scale-up concepts. (5)

Introduction to modeling of growth kinetics: General structure for kinetic models, overview of structure and unstructured models. (8)

SECTION-B

Sterilization of media: design of heat sterilization processes; kinetics; Sterilization in place and Cleaning in place concepts. (6)

Sterilization of air: Filter sterilization and kinetics. (4)

Design of fermentation media and optimization (6)

Aeration and agitation: various correlations and mass-transfer aspects, k_La determination (6)

RECOMMENDED BOOKS

S. No.	NAME	AUTHORS	PUBLISHERS
1.	Principles of Fermentation Technology.	Stanbury P.F. and Whitakar A.	Orgamon Press. 2nd edition, 1995
2.	Bioprocess Engineering Basic Concepts	2nd edition. Shuler M.L. &Kargi F.	Prentice Hall.2002.
3.	Bioreaction Engineering Principles.	Nielson J. Villadsen J. & Liden G.	3rd Edition, 2003, Springer US.
4.	Manual of Industrial Microbiology and Biotechnology.	Demain A.L. & Davis J.E.	1999 ASM Press, Washington DC Reprinted 2010
5.	Bioprocess Engineering Principles.	Pauline M. D.	Academic Press. An imprint of Elsevier.

Course Code	BIO 562
Course Title	Bioprocess engineering (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Bioprocess engineering (Theory)
Course Objectives (CO)	1. To impart the practical knowledge and skills to students how to analyze the biological mechanisms and reactions.
Course Outcome	1. Students will be able to perform biological reactions and understand the behavior of different enzymes to their substrates. 2. Students will learn the importance physical and chemical conditions for the proper functioning of enzymes.

SYLLABUS

List of Experiments:

1. Prepare a standard curve for the estimation of glucose by DNSA method.
2. Evaluate the hydrolysis of starch by amylase with respect to time.
3. Effect of metal ions on enzyme activity.
4. Calculate the effect of organic compounds on enzyme activity.
5. Fermenter studies of given organism (growth and enzyme production)
6. Isolation of amylase producing bacteria from soil.
7. Physical mutation of microbes for increasing enzyme production.

Course Code	BIO 513
Course Title	Animal Cell Culture and Bio-Technology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Students should have knowledge of animal cell structure, function and behavior
Course Objectives (CO)	1. Students will be able to explain the biology, growth and kinetics of animal cell culture. 2. Students will be able to describe techniques of cell culturing, cell characterization and scaling up of animal cell culture 3. Students will be able to illustrate the concept of transgenic, development techniques used and their applications in animal cell culture 4. Students will be able to explain stem cell biology and their application.
Course Outcome	1. Students are able to explain growth kinetics and factors affecting growth of animal cell culture. 2. Students are able to describe scaling up process of animal cell culture. 3. Students are able to understand how genetic engineering can be combined with animal cell culture. 4. Students are able to analyze stem cell biology and its application.

SYLLABUS

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will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.

SECTION-A

History and introduction of animal cell culture (2)
Organ, tissue and cell culture (their application, advantage and limitations)
Cell culture environment (cell adhesion, cell proliferation, cell differentiation and energy metabolism)

Culture growth conditions (media composition, types of media, their advantages and disadvantages, BSS, physiochemical and physiological factor, development of serum free medium) (4)

Animal cell growth characteristics and kinetics (1)

Primary cell culture (isolation of tissue, methods of establishing primary cell culture, development of cell line (subculturing and progagtion) (4)

Cell cloning (dilution cloning, conditioned medium, feeder layer, suspension cloning, monolayer cloning, interaction with substrate) (2)

Techniques used in animal cell separation (cell density and isopyknic, sedimentation, cell size and sedimentation velocity, antibody-based techniques, fluorescence-activated cell sorting etc. (3)

Cell characterization (importance, tissue markers assisted, morphological and microscopic, karyotyping, DNA content, RNA and protein expression, enzyme activity) (3)

Scale up culture- stirrer culture, continuous flow culture, air-lift fermentor culture, roller bottle culture, multisurface culture, multiarray disks, spirals and tubes) (3)

SECTION-B

Gene transfer in animal cells and its applications (3)

Stem cell biology (4)

Contamination (sources, types, monitoring, eradication, cross contamination) (3)

Cryo- preservation (rationale, acquisition, principles) (3)

Transgenes, transgenic animals including live stock and their application in bioreactors, aquaculture, silkmoth, past control, biodiversity conservation (6)

***In-vitro* fertilization, embryo transfer technology** (3)

Case studies (1)

Recommended Books

S. No.	Title	Authors	Publisher
1.	Animal Cell biotechnology	Griffith, J.B. and Spier, R.E	Acadamic pr., 1994, 6th edition
2.	Culture of Animal cell	Freshney, R.I.	Oxford University press, New York., 2009, 3rd edition

Course Code	BIO 563
Course Title	Animal Cell Culture and Bio-Technology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Animal Cell Culture and Bio-Technology (Theory)
Course Objectives (CO)	1. Students will be able to practice basic techniques used for isolating animal cell culture 2. Students will be able to illustrate methods of transformation and selection of clones in recombinant DNA technology
Course Outcome	1. Students are able to demonstrate basic techniques used for isolating animal cell culture 2. Students are able to illustrate basic techniques used for culturing and subculturing of cells for establishing animal cell culture

SYLLABUS

List of Experiments:

1. Familiarizing students with animal cell culture laboratory and major equipments used.
2. Preparation of animal cell culture medium.
3. Dissection of rat for recovery of organs for establishing animal cell culture.
4. Isolation and establishment of primary adherent animal cell culture using cold trypsinization.
5. Isolation and establishment of primary adherent animal cell culture using warm trypsinization.
6. Establishment of primary suspension cell culture using blood sample.
7. To perform subculturing of adherent cell line.
8. To perform counting of animal cells using hemocytometer.

Course Code	BIO 514
Course Title	Transport Phenomena (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment methods	
End Semester Assessment (University Exam)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Mathematical ability to solve analytically simple first and second order differential equations, concepts of heat and mass transfer, fluid flow and Process Calculations
Course Objectives (CO)	To provide engineering students the fundamentals to solve problems involving transport of momentum, energy and mass in biological and other systems using a unified approach.
Course Outcome	1. The students will be able to define the fundamental law of viscosity, heat transfer and mass transfer. 2. The students will be able to write shell balance for conservation of momentum, energy and mass. 3. The students will be able to employ these equations to obtain desired profiles for velocity, temperature and concentration. 4. The students will be able to apply dimensional analysis for problem solving.

SYLLABUS

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SECTION-A

Transport of momentum, heat and mass by molecular motion-Newton's law of viscosity, Fourier's Law of heat conduction, Fick's Law of Diffusion. (4)

Transport properties-Viscosity, Thermal Conductivity and mass diffusivity. (2)

Development of mathematical models of transfer processes through shell momentum balance for solving specific problems of transport of momentum in laminar flow or in solids in one dimension. (10)

Development of general differential equations of fluid flow and their applications in solving one-dimensional steady state and unsteady state problems of momentum transfer. (6)

Emphasis on the analogy between momentum heat and mass transfer with respect to transport mechanism and governing equations. (2)

SECTION-B

Development of mathematical models for transfer processes through shell energy balance and shell mass balance for solving specific problems of transport of heat and mass in one dimension. (14)

Development of general differential equations for heat transfer and mass transfer and their applications in solving one-dimensional steady state and unsteady state problems of heat and mass transfer. (4)

Dimensional Analysis. (3)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1.	Transport Phenomena	R.B.Bird, W.E.Stewart and E.N. Lightfoot	John Wiley and Sons (Student Edition) 2nd Edition 2005.
2.	Fundamentals of Momentum, Heat, and Mass Transfer	J.R.Welty, C.E.Wicks , R.E. Wilson and G.L. Rorrer	John Wiley and Sons Inc. 5th Edition 2007
3.	Transport Phenomena in Biological Systems	George A. Truskey, Fan Yuan, David F. Katz	Pearson, Prentice Hall 2nd Edition 2009

Course Code	BIO 564
Course Title	Transport Phenomena (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assesement methods	
End Semester Assesement (University Exam)	00
Continous Assesement (Sessional)	50
Course Prerequisites:	Transport Phenomena (Theory)
Course Objectives (CO):	To demonstrate and validate the theoretical concepts.
Course Outcome:	Application of the theoretical concepts.

SYLLABUS

List of Experiments:

1. Measurement of density of a liquid.
2. Measurement of viscosity of a liquid.
3. Determination of Thermal Conductivity of solid.
4. Determination of Heat transfer coefficient. (Natural convection)
5. Determination of heat Transfer coefficient (Forced convection).
6. Determination of mass transfer coefficient for vaporization of naphthalene in air.
7. Determination of mass transfer coefficient as a function of gas mass velocity in a wetted wall column.

Course Code	BIO 515
Course Title	Bioinstrumentation (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	1. Knowledge of human physiology 2. Basics of signal and systems 3. Basics of electrical and electronic instrumentation and measurements
Course Objectives (CO)	1. The course aims at introducing the students to the cellular processes leading to generation of biopotentials. 2. To make them understand the design and application of biomedical instruments. 3. To represent them to tools of data recording, processing and analysis. 4. To make them aware of the different signal and systems and how to analyse them.
Course Outcome	1. The students learn about the origin of biopotentials at the cellular level. 2. The students apply the knowledge of biopotentials to understand the working of the biomedical devices involved in diagnosis and treatment of disease 3. The students will be able to analyze the various tools of data recording, processing and analysis. 4. The students are able to differentiate and analyses the frequency response of different signals.

SYLLABUS

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SECTION-A

Introduction: Problems unique to bioinstrumentation; Lab View: A graphical programming language for virtual instrumentation	(2)
Basic Principles: Review of system concepts input/output characteristics, the black box signals linear, time-invariant systems static characteristics dynamic characteristics time versus frequency domain analysis	(2)
Fourier Analysis; Fourier transforms of common and important signals windowing Discrete Fourier Transforms The Fast Fourier Transform Spectrum Analyzers windows Frequency Analysis transfer functions, frequency response magnitude and phase functions signals through systems 'ideal' and 'best' systems time vs frequency domain filters how to measure frequency response in the laboratory	(5)
Sample systems in the time and frequency domains; 0th, 1st, and 2nd order systems; Non-ideal systems noise and signal-to-noise ratio; nonlinearities and distortion products	(2)
wave-analyzer synchronous [lock-in] detection modulator, demodulator digital techniques analog to digital conversion signal averaging V. Transducers and associated electronics displacement transducers resistive strain gages bridge circuits capacitive displacement transducers piezoelectric transducers optical transducers temperature transducers	(7)
Hemodynamics Blood pressure measurement- Non-invasive- vascular unloading technique, Auscultatory method; invasive blood pressure monitoring- fluid-filled catheter manometer, catheter tip pressure manometer	(2)
Blood flowmeters- electromagnetic flowmeters, ultrasonic blood flowmeter Cardiac output measurement- Indicator dilution method(dye dilution, thermal dilution)	(2)

SECTION B

Bioelectric Potentials-Electrophysiology Origins of biopotentials:Neural and muscular, resting membrane potential, graded potential, action potential, local field potential, stimulators discriminators, histograms, evoked potentials- example: evoked potential audiometry	(8)
Electrodes: Electrode- electrode :electrolyte interface, electrode skin interface, polarizable and non-polarizable electrodes, types of electrodes, surface electrodes, internal electrodes, micro-electrodes, amplifiers and pre- amplifiers	(3)
Recording and Stimulating Systems, Putting it all together interference minimization and rejection stimulus isolation shielding grounding ground-	(4)

loops; Sample recording system: electrocardiography (ECG), electromyography (EMG), and electroencephalography (EEG)- lead placement, waveforms and instrumentation.

Therapeutic cardiac devices: Pacemakers and Defibrillators – external and implantable, performance aspects, power source and electrodes (5)

Introduction to medical imaging: Ultrasound, magnetic resonance imaging and computed tomography (3)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(S)	PUBLISHER
1	Handbook of Biomedical Instrumentation	Khandpur, R.S.	Tata McGraw Hill(2003)2nd edition
2	Medical Instrumentation application & Designs	Webster, G. J.	John Wiley &Sons, Inc.(2009)4th edition
3	Principles of applied Biomedical Instrumentation	Geddes, L.A. and Baker, L.E.	A Wiley Interscience publication (2008) 3rd edition
4	Electrical and Electronic Measurements and Instrumentation	Sawhney, A. K.	Dhanpat Rai and Sons
5	Transducers and Instrumentation	Murthy, D.V.S.	Prentice Hall of India, New Delhi, Tenth Edition
6	Communication Systems	Haykin,S.	Wiley India Limited, 4th Edition

BIO 516 Training of 4- 6 weeks after 4th semester exams

SYLLABUS
B.E. BIOTECHNOLOGY

SIXTH SEMESTER

Course Code	BIO 611
Course Title	Recombinant DNA Technology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Students should have prior knowledge of basic structure and functions of DNA, RNA and proteins
Course Objectives (CO)	1. Students will be able to explain the basic concept of gene cloning along with isolation and purification of different types of DNA molecules 2. Students will be able to describe different vector molecules and enzymes used in gene cloning experiments 3. Students will be able to analyze gene expression, regulation and protein-protein interaction 4. Students will be able to demonstrate the applications of recombinant DNA technology in the fields of Medicine, Agriculture, Forensic and Environment
Course Outcome	1. Students are able to explain the basis of isolation and purification of different types of DNA molecules 2. Students are able to describe different vector molecules and enzymes used in gene cloning experiments 3. Students are able to explain gene expression, regulation and protein-protein interaction.

4. Students are able to analyze the applications of recombinant DNA technology in the fields of Medicine, Agriculture, Forensic and Environment

SYLLABUS

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SECTION-A

Gene cloning-concept and importance (1)

Isolation and purification of plasmid DNA from bacterial cells (2)

Genomic DNA isolation from bacterial, plant and animal cells and its quantification (2)

Molecular tools in Recombinant DNA technology- Vectors for *E. coli* (Plasmids, Phages, Cosmids, Fosmids, Phagemids, BAC), Vectors for Eukaryotes (YEPs, YIPs, YRPs, YAC), Vectors for plants (Ti and Ri plasmids, caulimoviruses, geminiviruses), Vectors for animals (P-elements, baculovirus, adenovirus, papillomavirus and retrovirus) (8)

Restriction and DNA Modifying enzymes (Polymerases, Reverse Transcriptase, Ligases, Alkaline phosphatase, Terminal deoxynucleotide transferases, Nucleases) (5)

PCR, its types and applications (1)

SECTION -B

Methods of clone identification- Direct selection method, screening gene library using probe hybridization, immunological screening of translational product (5)

Methods to study gene location – Use of restriction maps, chromosomal gel electrophoresis and FISH (2)

Gene structure analysis-Introduction to sequencing and their detailed methodologies (3)

Studying expression of a gene - Electron microscopy of nucleic acid molecule, S_1 nuclease and primer extension methods, RT-PCR, RACE (2)

Studying regulation of gene expression-Finding protein binding sites (gel retardation, (4)

DNAase1 footprinting, modification interference assay), deletion analysis, *in-vitro* mutagenesis, siRNA)

Studying protein-protein interactions- Phage display and yeast two hybrid (1)

Expression studies of foreign genes in research- feature of expression vector, expression in *E. coli,* eukaryotic cells, animal cells and plant cells. (3)

Safety measures and regulations for recombinant DNA work, ethical concerns with pharming (2)

Applications of recombinant DNA technology in the fields of Medicine, Agriculture, Forensic and Environment (4)

Recommended Books

S. No.	Title	Authors	Publisher
1.	Recombinant DNA: Genes and Genomes	Watson, J.D., et al.	McGraw Hill Publications, 2007, 3rd edition
2.	Gene Cloning and DNA analysis: An Introduction	Brown, T.A.	Blackwell Science., 4th ed.
3.	Molecular Biology of the Gene	Watson, J.D.	Benjamin, Cummings, Pearson education, Schweiz AG, Germany, 2004, 4th ed.
4.	Molecular Biology of Cell	Alberts, B. *et al*.	Garland Publishers, 1994

Course Code	BIO 661
Course Title	Recombinant DNA Technology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Recombinant DNA Technology (Theory)
Course Objectives (CO)	1. Students will be able to understand practical aspects used in DNA isolation techniques 2. Students will be able to demonstrate digestion and ligation of various DNA molecules for generating recombinant molecules
Course Outcome	1. Students are able to explain practical aspect of DNA isolation and quantification techniques used in recombinant DNA technology 2. Students are able to describe the use of various enzymes used for DNA manipulation for generating recombinant molecules

SYLLABUS

List of Experiments:

1. In-situ oligonucleotide synthesis.
2. Extraction of genomic DNA from yeast cells and its analysis by agarose gel electrophoresis.
3. Amplification of desired DNA fragment using PCR and its verification by agarose gel electrophoresis.
4. Isolation of plasmid DNA from *E. coli* and its analysis by agarose gel electrophoresis
5. Digestion of plasmid DNA by restriction endonucleases and its analysis by agarose gel electrophoresis.
6. Ligation of two digested DNA molecules using T_4 ligase enzyme and transformation assay to obtain recombinant molecule.
7. Induction of protein expression of a gene cloned in an expression vector in *E. coli* using inducer molecule.

Course Code	BIO 612
Course Title	Bioinformatics (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of biomolecules like DNA, RNA, proteins and some fundamentals of computer.

Course Objectives (CO)

1. To introduce to the students objectives and applications of bioinformatics, genome sequencing projects and the basic concepts of different databases.
2. To make students understand the use of databases in protein and nucleic acid sequence analysis.
3. To introduce gene prediction in prokaryotic and eukaryotic genomes, prediction of protein secondary structure and three-dimensional structure.
4. To understand concepts of molecular modeling and use of molecular graphics packages, computer aided drug design.

Course Outcome

1. Students will be able to explain objectives and applications of bioinformatics.
2. Students will be able to differentiate between different databases.
3. Students will be able to explain various computational tools used in sequence analysis, gene prediction, protein structure prediction and 3D structure analysis.
4. Students will be able to describe concepts of molecular modeling and computer aided drug design.

SYLLABUS

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SECTION-A

Introduction to Bioinformatics: (5)

History of Bioinformatics, Objectives and applications of Bioinformatics, Genome sequencing projects, Human Genome Project.

Introduction to databases: (8)

Basic concept of database, Type of databases:

Literature Databases: PUBMED, MEDLINE.

Primary Sequence and Structural databases: GenBank, EMBL, DDBJ, UNIPROT, PDB, PDBsum, Sequence and Structure file formats.

Genome databases: Ensembl, TIGR, Maize GDB.

Secondary Sequence and Structural databases: TrEMBL, PROSITE, BLOCK, SCOP, CATH.

Database retrieval and deposition systems: SRS, Entrez, Bankit, Seqin, Webin, AutoDep.

Sequence Analysis: (5)

Scoring matrices: PAM and BLOSSUM.

Sequence alignment concepts.

Database searches for homologous sequences: BLAST, PSI-BLAST and PHI-BLAST.

Multiple sequence alignment: CLUSTALW, T-Cofee.

Molecular phylogenetics: (5)

Terminology of phylogenetic tress: Branches, Nodes, Clade, Taxa, OUT, Rooted and Unrooted trees.

Forms of tree representation: Phylogram, Cladogram, Dendrogram.

Phylogenetic tree construction methods: Distance and character based methods.

SECTION-B

Gene prediction: (6)

Structural characteristics like promoter regions splice sites, polyA sites, exon, intron and regulatory regions in prokaryotic and eukaryotes genomes, Gene prediction softwares like ORF finder, GenScan, Grail, Glimmer.

Protein structure prediction: (5)

Prediction of protein secondary structure from the amino acid sequence: Chou-Fasman/GOR method, PSIPRED.

Prediction of three-dimensional protein structure: Homology-based structure prediction, Fold recognition and *ab initio* methods for structure prediction.

Introduction to the concepts of molecular modeling: (6)

Molecular mechanics and Molecular dynamics simulations: concept of force field, Energy Minimization and related methods for exploring the energy surface.
Use of molecular graphics packages: Rasmol, spdbviewer, Cn3D.

Computer aided drug design: (5)

Drug discovery process, Role of molecular recognition in drug design, concepts of docking and Quantitative structure activity relationships (QSAR) in drug design

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1.	Bioinformatics- A Beginners Guide	Claverie, J. M. and Notredame, C.	Wiley Publishing, Inc. (2003)
2.	Bioinformatics Concepts, Skills and Applications	Rastogi, S. C., Mendiratla, N. and Rastogi, P.	CBS Publishers and Distributors, New Delhi (2003) Ist edition
3.	Introduction to Bioinformatics	Attwood, T. K. and Parry Smith, D.J.	Pearson Education Ltd. (2007) Ist edition
4.	Bioinformatics Databases, Tools and Algorithms	Bosu, O. and Thukral, S. K.	Oxford University Press (2007)
5.	Bioinformatics Sequence, Structure and Databanks	Higgins, D. and Taylor, W.	Oxford University Press (2000)
6.	Bioinformatics: Principles and Applications	Ghosh, Z. and Mallick, B.	Oxford University Press (2008)
7.	Bioinformatics Sequence & Genome Analysis	Mount, D. W.	CBS publishers and distributors, New Delhi(2004) 2nd edition
8.	Structural Bioinformatics	Bourne, P. E. and Weissig, H.	John Wiley and Sons publications (2003)
9.	Bioinformatics Computing	Bergeron, B.	Pearson Education (2003)

Course Code	BIO 662
Course Title	Bioinformatics (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Bioinformatics (Theory)
Course Objectives (CO)	1. To make students understand the use of various computational tools available online for retrieving DNA and protein sequences, similarity searches among them, phylogenetic analysis, gene prediction, 2D and 3D protein structure analysis.
Course Outcome	1. Students will be able to study and analyse various biological databases at NCBI, Expasy and RCSB 2. Students will be able to retrieve DNA and protein sequences from databases. 3. Students will be able to use various computational tools available online for similarity searches, phylogenetic analysis, gene prediction, 2D and 3D protein structure analysis for DNA and protein sequences.

SYLLABUS

List of Experiments:

1. To study and analyze various biological databases at NCBI, Expasy and RCSB
    a. Nucleic acid sequence databases like Gene Bank, EMBL etc.
    b. Protein sequence databases like UNIPROT.
    c. Structural databases- PDB, NBD.
2. To retrieve sequences from NCBI/EBI/ExPasy using ENTRZ, SRS.
3. Similarity searches using various tools like BLAST N, BLAST P, BLAST X.
4. Pairwise sequence alignment between the given two sequences using any two variants of BLOSUM in BLAST.
5. Multiple sequence alignment and phylogenetic analysis using CLUSTALW / T-Cofee.
6. To predict gene/ORF for genomic DNA sequences of prokaryotic and eukaryotic origin.
7. To analyze protein sequence using Secondary Structure prediction Methods:

Chou-Fasman/GOR method, PSIPRED etc.

8. To down-load structures of proteins in software like RASMOL, SPDBV and analysis of structures in these software.
9. Energy minimization using SPDBV.

Course Code	BIO 613
Course Title	Bioreactor Design & Operation
Type of Course	Core
L T P	4 0 0
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Bioprocess engineering concepts
Course Objectives (CO)	1. To summarize the characteristics of biological systems. 2. Interpretation of different types of reactors and their non-ideal behavior. 3. To illustrate control and instrumentation of various process parameters. 4. Demonstration of modeling and stability of a reactor process.
Course Outcome	1. Knowledge of different types of microorganisms and their effect on the reactor design. 2. Understanding of performances of different types of reactors and their non-ideality calculation. 3. Knowledge of principles of measurement of various process parameters and their control. 4. Learning about the fermentation dynamics and their stability in terms of operation.

SYLLABUS

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SECTION-A

Biological systems: Organism selection; bacterial, yeast and fungal cultures; Effect of microorganism type and culture characteristics on bioreactor design and operation. (7)

Ideal Reactors: Batch reactor (Closed and fed-batch), continuous reactors; PFTR, CSTR design equations. Reactors for biomass growth; reactors in series; recycle reactors; overview of pneumatically agitated bioreactors; Membrane bioreactors and Photo bioreactors. (10)

RTD in reactors: Models for non-ideal reactors; Tanks in series and dispersion models. (6)

SECTION-B

Instrumentation and control of various parameters in bioreactors for Dissolved oxygen, foam,pH, temperature, flow, pressure, microbial biomass, CO_2 etc; Methods of measuring process variables and control systems: Proportional, Proportional integral and Proportional integral derivative. (10)

Bioreactor modeling and stability: Fermentation dynamics, Biomass production and dilution factor, Thermal stability concepts. (6)

Mechanical design Concepts: Application to continuous sterilizers, RTD concepts, Application of design principles. (6)

RECOMMENDED BOOKS

S. No.	NAME	AUTHORS	PUBLISHERS
1.	Bioprocess Engineering Basic Concepts	Shuler M.L & Kargi F. P.H	2nd edition, Prentice Hall.
2.	Bioreactor Sytem Design	Asenjo J.A. & Merchule J.C. Dekker.	C R C Pr. 1st edition, 1994. (Eds.) .
3.	Basic Bioreactor Design	Van't R et KK. & Tramper J. Marcel Decker	1991 C R C Pr.
4.	Bioprocess Engineering Principles	Pauline M. D.	Academic Press, An imprint of Elsevier.

Course Code	BIO 614
Course Title	Downstream Processing (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of various bioprocesses of industrial importance and their components
Course Objectives (CO)	1. To make students understand the difference between upstream and downstream processing and different phases of downstream processing of different bio products 2. To teach students about the various unit operations involved in the isolation and extraction of bio-products from the fermentation broth 3. To educate students about different methods of concentration, purification and final polishing of the bio-product before commercial use
Course Outcome	1. Students are able to identify different stages of downstream processing 2. Students can explain the principles and working of different unit operations for the isolation and extraction of bio-products 3. Students can apply different methods for the concentration, purification and final polishing of bio-products

SYLLABUS

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SECTION-A

An overview of Bio-separations- Role and importance of downstream processing

in biotechnological processes, various downstream process steps; Characteristics of bio-molecules and fermentation broth (2)

Cell disruption- mechanical, enzymatic and chemical methods (3)

Solid-liquid separation- Filtration**-** principle, basic theory, equipment

Centrifugation**-** principle, types of centrifugal separations-differential and density gradient; types of laboratory and industrial centrifuges (6)

Product isolation- Adsorption**-** phenomenon of adsorption, types of adsorption, types of adsorbents, introduction to adsorption isotherms (linear, Langmuir, Freundlich)

Liquid- liquid extraction**-** principle and process, modes of extraction, equipment for extraction; aqueous two-phase extraction

Distillation for solvent recovery**-** batch and continuous, fractional, vacuum, azeotropic, and steam distillation

Precipitation- precipitation of proteins by different methods (11)

SECTION-B

Membrane separation methods for product isolation- process, membrane materials, Ultrafiltration, microfiltration, nanofiltration, Reverse osmosis, Dialysis, electrodialysis (2)

Product purification- Chromatography**-** importance as a purification technique, modes of chromatography (paper, thin layer and column), types of chromatography- adsorption, ion exchange, gel permeation, affinity, GC, HPLC, reverse phase, hydrophobic interaction- their principle, mode of operation and applications

Electrophoresis- principle and application of analytical and preparative electrophoretic techniques in product purification (14)

Product polishing- Crystallization**-** principle and process, applications in bioprocessing

Drying**-** need and mechanism, mode of operation, equipment, lyophilization (5)

Product recovery- ethanol, citric acid, penicillin, recombinant insulin from *E.coli* (2)

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1	Principles of Fermentation Technology	Stanbury, P.F, Whitaker, A. and Hall, S.J.	Butterworth-Heinemann (1999) 2nd ed.
2	Bioseperations –Principles and Techniques	Sivasanker, B.	Prentice-Hall of India (2005)
3	Principles and Techniques of Practical Biochemistry	Wilson, K. and Walker, J	Cambridge University Press (2000) 5th edition
4	Introduction to Biochemical Engineering, Chemical engineering series	Rao, D.G	Tata McGraw-Hill Education (2005)
5	Bioseparations – Downstream Processing For Biotechnology	Belter, P.A., Cussler, E.L. and Wei-Houhu	Wiley Interscience Pub. (1988)

Course Code	BIO 664
Course Title	Downstream Processing (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Downstream Processing (Theory)
Course Objectives (CO)	1. To impart to students working knowledge of different methods and techniques used during different stages of downstream processing of bio-molecules
Course Outcome	1. The students are able to isolate and enrich bio-molecules using different techniques pertaining to downstream processing

SYLLABUS

List of Experiments:

1. Separation of microbial flora from the given sample by filtration method
2. Cell lysis by ultrasonication
3. Lyophilization of the given sample
4. Thin Layer Chromatography (TLC) of the given sample (sugars/ amino acids)
5. Determination of specific amylase activity
6. Ammonium sulphate precipitation of the given protein
7. Protein concentration by Dialysis

Course Code	BIO 615
Course Title	Open Elective (Biomaterials)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of human anatomy and physiology and basics of immunology
Course Objectives (CO)	1. The course aims at introducing the students to properties of biomaterials 2. To make them aware of different types of tissue grafts 3. The students learn about the immunological response to the grafts 4. To explain to them about the utilization of different classes of synthetic polymers and biopolymers as implant material in various organ systems
Course Outcome	1. To students learn about the mechanical, thermal and surface properties of biomaterials 2. Learn about the application of synthetic and biopolymer as implant material for soft and hard tissues 3. The students learn about the interaction of implant material with the body tissues 4. The students are able to identify the approaches to prevent rejection of the implant

SYLLABUS

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SECTION-A

Characterization and classification

Physico-chemical properties of biomaterials: Bulk and surface properties, mechanical, tribological, chemical, thermal, electrical properties (6)

Classes of biomaterials: Structure and characteristic feature (4)

Metallic alloys: Stainless steel, cobalt- chromium alloys, titanium based alloys, metallic corrosion (4)

Ceramics: Bio-inert ceramics- alumina, zirconia; bioresorbable ceramics- hydroxyapatite and surface reactive ceramics- bioglass

Polymers:

Synthetic polymers: Polyethylene, polypropylene, perfluorinated polymers, acrylic polymers, polyurethanes, polyamide, silicones, smart polymers (4)

Biopolymers: Collagen, elastin, proteoglycans, cellulose, chitin and its derivative (4)

SECTION B

Biocompatibility

Host Response to Biomaterials: Blood composition, biomaterial-blood interaction, blood clotting, grafts and immune rejection processes, wound healing process, tissue responses to materials. (4)

Application of biomaterial in systems

Cardiovascular implants: Anatomy of heart and blood vessels, blood rheology, cardiac valves replacement, pacemaker, vascular grafts, blood substitutes. (4)

Orthopedic implants: Bone composition, temporary fixation devices, hip joint and knee joint replacement, knee joint repair. (4)

Biomaterials in ophthalmology: Anatomy of eye, viscoelastic solution, contact lens and optical implants- intra-ocular lens, artificial cornea. (3)

Dental Materials : Tooth composition, impression materials, filling and restorative materials, oral implants (2)

Soft tissue Applications: Skin, skin sutures, soft tissue fillers, maxillofacial implants, urological implants (2)

Case study- Performance review of implanted biomaterial from current literature (2)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(S)	PUBLISHER
1	Biomaterials	Bhat, S.V.	Alpha Science International (2005) 2nd edition
2	Biomaterials Science: An Introduction to Materials in Medicine	Edited by: Ratner, B.D., Hoffman, A.S., Schoen, F.J. and Lemons, J.E.	Academic Press (2013) 3rd edition
3	Biomaterials: An Introduction	Park, J. and Lakes, R.S.	Springer Science+ Business Media (2007) 3rd edition

SYLLABUS
B.E. BIOTECHNOLOGY

SEVENTH SEMESTER

Course Code	BIO 701
Course Title	Environmental Biotechnology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4

Course Assessment Methods

End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50

Course Prerequisites Basic concepts of environmental pollution and general reaction kinetics.

Course Objectives

1. To introduce the student to concepts and types of Environmental Pollution.
2. To understand the methods of waste water treatment.
3. To understand the mechanisms of Solid Waste management.
4. To understand the Microbial Leaching and Mining.
5. To introduce the concepts of Environmental Genetics.

Course Outcome

1. Students will be able to explain learn about environmental pollution, Biodegradation, Bioremediation-definitions and examples.
2. Students will do waste water treatment, kinetics and methods.
3. Students will be performing in the area of solid waste management.
4. Students will be able to explain Degradative plasmids, release of genetically engineered microbes in environment.

SYLLABUS

Note: *The question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.*

SECTION-A

Introduction: Environmental Pollution: Sources and effects. (3)

Biodegradation and Bioremediation - definitions and examples. (3)

Waste Water Treatment: Aerobic and Anaerobic waste water treatment. Kinetics for waste water treatment processes. Different type and design of Aerobic and Anaerobic reactors, (14) Emerging biotechnological processes in waste water treatment. (3)

SECTION-B

Solid Waste management: Biodegradation of pollutants, Treatment processes for solid waste, Use and Management, Bioremediation of contaminant lands. Hazardous wastes: source management and safety. (10)
Microbial Leaching and Mining: Recovery of metals from solutions, microbes in petroleum extraction, microbial desulphurization of coal. (8)

Environmental Genetics: Degradative plasmids, release of genetically engineered microbes in environment. (4)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1	Wastewater Engineering : Treatment And Reuse	Metcalf & Eddy	McGraw Hill Publications 4th Edition, 2012
2	Environmental Biotechnology	T. Srinivas	New Age International (P) Ltd., 2008
3	Principles of Environmental Science &Technology	K. Saravana, S. Ramachandran.	New Age International (P) Ltd., 2008
4	Environmental biotechnology: Principles and Applications	J B. E. Rittman and. P. L. McCarty	McGraw Hill Publications, 2009

Course Code	BIO 751
Course Title	Environmental Biotechnology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Environmental Biotechnology (Theory)
Course Objectives (CO)	1. The course aims to provide the practical training of estimation of Environmental Pollutant such as aromatic compounds. 2. To perform the measurement in waste water treatment such as DO and COD.
Course Outcome	1. Learn about measurement in waste water treatment. 2. Learn about Environmental Pollutant such as aromatic compounds. 3. To understand about biochemical calculation in waste water treatment.

SYLLABUS

List of Experiments:

1. To estimate dissolved oxygen content of a given water sample.
2. Estimation of phenolic compounds in the drinking water and effluent sample.
3. Quantification of total detergents /surfactants content in drinking water.
4. Assay of soil urease activity by colorimetric estimation of ammonia release.
5. Estimation of chemical oxygen demand of a given water sample.
6. To measure biochemical oxygen demand of a sample by titrimetric method.
7. Isolation of poly aromatic hydrocarbons(PAHs) degrading microorganisms from soil.

Course Code	BIO 702
Course Title	Food Biotechnology (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of microbiology concepts

Course Objectives (CO)

1. To introduce students about history of microorganisms in food, primary sources of microorganisms in foods.
2. To familiarize students with synopsis of common food borne bacteria, fungi and yeasts.
3. To understand about Extrinsic & Intrinsic parameters of foods.
4. To make their understanding in relating above parameters with food spoilage, food borne diseases, food preservation.
5. To introduce about methods for diagnosis of microbial contents of food, food biosensors.

Course Outcome

1. Students will be able to describe history of microorganisms in food, primary sources of microorganisms in foods.
2. Students will be able to explain factors affecting food.
3. Students will be able to explain role of microorganisms as food spoilage, food borne diseases and fermented food.
4. Student will be able to describe various molecular approaches to diagnose microbial contents of food.

SYLLABUS

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SECTION-A

History of Microorganisms in food, Primary sources of Microorganisms in foods, Synopsis of common food borne bacteria, fungi and yeasts. (11)

Incidence & Behavior of Microorganisms in foods, Extrinsic & Intrinsic parameters of foods, Role and Significance of Microorganisms as Single cell proteins, Food value of Mushrooms, Yeasts, Production of Fermented foods. (10)

SECTION-B

Food types and their physical & chemical properties, Food Spoilage, Food Borne diseases. (13)

Food Preservation, Diagnosis of microbial contents of food: Classical & Molecular approach, Food Biosensors. (11)

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RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1.	Introductory Food Microbiology	Modi, H. A.	Aavishkar Publishers and Distributors, Jaipur (India) (2007)
2.	Food Microbiology	Adams, M.R. and Moss, M.O	Turpin Distribution Service Ltd (1995)2nd edition
3.	Modern Food Microbiology	Jay, J.M.	Springer (2005) 7th edition
4.	Food Microbiology	Frazier W.C. and Westhoff, D.C.	Tata Mc Graw Hill pubishing company(2008) 4th edition
5.	Food Biotechnology: Techniques and Applications.	Mittal, G. S.	CRC Press (1992)

Course Code	BIO 752
Course Title	Food Biotechnology (Practical)
Type of Course	Core
L T P	0 0 2
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	Food Biotechnology (Theory)
Course Objectives (CO)	1. To develop skills in observing contaminated foods through different tests and microscope**.**
Course Outcome	1. Students will be able to develop skills in observing contaminated foods through different tests and microscope.

SYLLABUS

List of Experiments:

Microbiological Examination of food/s. Enumeration and detection of food borne organisms. Estimation of quality of milk-by dye reduction, direct microscopic count, Determination of diacetyl, titrable acidity in the milk sample.

Course Code	BIO 703
Course Title	Plant Tissue Culture (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Knowledge of plant cell biology and physiology
Course Objectives (CO)	1. The course aims at familiarizing the students with fundamental aspects of plant tissue culture, 2. Explain the concept of totipotency to the students 3. Explain the utilization of tissue culture systems for plant improvement 4. Learn about the techniques for optimized production of metabolites.
Course Outcome	1. The students understand the basic concepts in plant tissue culture 2. Learn different methods and techniques utilized in plant tissue culture 3. Learn about recent advances in plant tissue culture and secondary metabolite production techniques 4. Implementation of plant tissue culture techniques for research and commercial application

SYLLABUS

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SECTION-A

Introduction, requirements and Techniques. (6)

Tissue Culture Media and Cell Culturing. (6)

Cellular Totipotency, Somatic Embryogenesis, Synthetic seeds. (6)

Haploid Production, Zygotic Embryo Culture, Morphogenesis in the culture of seeds with partially differentiated embryos. (5)

SECTION B

Microsurgical experiments, Morphogenic potential of the embryo callus, practical applications. (2)

In-Vitro Pollination and Fertilization: Introduction, Terminology, In-Vitro Pollination, Applications. (5)

Genetic engineering and production of pathogen free plants: Gene expression, genetic stability, and field performance (5)

Introduction, Strategies used to optimize product yield, commercial aspects. Germplasm storage: Introduction, long term Storage, Short or Medium term storage. (10)

RECOMMENDED BOOKS

S.No.	NAME	AUTHOR(S)	PUBLISHER
1	Plant Tissue Culture: Techniques and Experiments	Smith, R.H.	Academic Press(2012) 3rd edition
2	Plant Biotechnology: The Genetic Manipulation of Plants	Slater, A., Scott, N.W. and Fowler , M.R.	Oxford University Press (2008) 2nd edition
3	Plants from Test Tubes: An Introduction to Micropropagation	Kyte , L. and Kleyn, J.G.	Timber Press(1996) 3rd edition
4	Plant Tissue Culture: Theory and Practice	Bhojwani, S.S. and Razdan, M.K.	Elsevier Science (1996) 1st edition

Course Code	BIO 704
Course Title	Bioanalytical Techniques (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4

Course Assessment Methods

End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50

Course Prerequisites: Introductory knowledge about bioanalytical instruments and techniques

Course Objectives (CO): 1. To impart the knowledge to student about basic concepts behind biotechniques

2. To make the student understand importance of biotechniques

Course Outcome: 1. Student will know about the utilization of different techniques for different analytes

SYLLABUS

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SECTION-A

Spectrophotometry (UV and Visible): Principle, single beam and double beam spectrophotometer, factors influencing the absorption spectra, overview of empirical rules, solvent perturbation method and difference spectroscopy; various applications of absorption spectroscopy with respect to biotechnology. (5)

Spectrofluorimetry: Principle, significance and various details related to instrumentation. (3)

Atomic absorption Spectrophotometry: Principle, instrumentation details, various interferences in atomic absorption spectroscopy and applications. (4)

Infrared and Raman Spectroscopy: Principle, factors deciding the spectra, instrumentation, overview of different class of compounds and their IR spectra. Introduction to Raman scattering. (4)

Nuclear Magnetic resonance: Phenomena of resonance, instrumentation, diamagnetic shielding, anisotropy, chemical shift, free induction decay (FID), population distribution of nuclei, and prediction of NMR spectra on the basis of (n+ 1) rule for basic class of compounds. Overviews of electron spin resonance spectroscopy (ESR) and magnetic resonance imaging (MRI). (8)

SECTION-B

Electron Microscopy: Transmission and scanning electron microscopy, significance of vacuum, basic instrumentation for TEM and SEM, sample preparation for electron microscopy. Overview of Atomic force microscopy and tunneling microscopy with respect to their working principle and comparison with other scanning techniques. (5)

Crystallography and X-ray diffraction: Introduction to x-ray and general theory and instrumentation, Bragg's law, various techniques to determine crystal structure. (5)

Radioisotope techniques: Radiotracers, units of radioactivity measurement, proportional and scintillation counters, introduction to autoradiography and nuclear medicine. (6)

Mass Spectroscopic Techniques: Introduction to mass-spectroscopy, significance, instrumentation details of a mass-spectrometer, ionization techniques, single and double focusing, alternate mass separation techniques- time of flight and quadruple. Interface of mass-spectra with liquid and gas chromatography (LC-MS and GC-MS). (5)

RECOMMENDED BOOKS

S.NO.	Name	Author	Publisher
1.	Principles and techniques of practicalactical biochem.	Keith Wilson & John Walker	(5^{th} Edition) Cambridge Uni. Press 2000
2.	Physical Biochem.	David Friefelder	Freeman & Co. ,New York, 2nd edition

Course Code	**:**BIO 754
Course Title	**:**Bioanalytical Techniques (Practical)
Type of Course	**:**core
L T P	**:** 0 0 2
Credits	**:** 1

Course Assessment Methods

End Semester Assessment (University Exam.)	:00
Continuous Assessment (Sessional)	:50

Course Prerequisites	**:** Understanding of various analytical techniques in terms of their fundamental principles and applications.
Course Objectives (CO)	**:** To learn different techniques for different types of applications.
Course Outcome	**:** Students shall learn to apply different analysis techniques for their research purposes independently.

SYLLABUS

List of Experiments:

1. To determine maximum wavelength (λ_{max}) for a given colored solution.
2. To confirm the Beer's Lambert law for the given coloured solution.
3. To elucidate a structure of a given chemical compound using NMR.
4. To investigate different samples for the elemental composition using X-ray fluorescence.
5. To confirm the presence of different functional groups using FT-IR spectroscopy.
6. Rapid protocol for lipase/enzyme detection.
7. Hands on training on HPLC.

Course Code	BIO 705
Course Title	Minor Project (Practical)
Type of Course	Core
L T P	0 0 4
Credits	2
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50

Course Code	BIO 706
Course Title	Training of 6 weeks after 6^{th} semester
Credits	1
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50

SYLLABUS
B.E. BIOTECHNOLOGY

EIGHTH SEMESTER

Course Code	BIO 801
Course Title	Major project (Practical)
Credits	2
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50

Course Code	BIO 802
Course Title	Enzyme Catalyzed Organic Synthesis (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4

Course Assessment Methods

End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50

Course Prerequisites Introductory Enzyme Technology.

Course Objectives

1. To introduce the student to concepts of biocatalysts and understand about industrial applications of biocatalysts.
2. To understand the methods of immobilized system of Biocatalysts.
3. To understand the mechanisms of Stereo selective biocatalysts.
4. To understand the chiral pharmaceutical intermediate.

Course Outcome

1 Students will be able to explain biocatalysts and applications of biocatalysts.
2 Students will do various methods of Immobilization.
3 Students will be able to explain about synthesis of chiral pharmaceutical intermediate such as synthesis of ACE inhibitors.
4 Students will be able to explain synthesis of anticholesterol drug by biocatalysts routs , calcium channel blocking drugs, potassium channel openers, antiviral

SYLLABUS

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SECTION-A

Biocatalysis: Definition of Biocatalysis, advantages and disadvantages of Biocatalysis over chemical catalysis. (10)

Different types of Biocatalysis; microbial, enzymatic and immobilized system of Biocatalysis; current industrial Biocatalysis with different enzymes. (7)

Immobilized enzymes for Biocatalysts. (6)

SECTION-B

Stereo selective biocatalysts for the synthesis of chiral pharmaceutical intermediate such as synthesis of ACE inhibitors, definition, mode of action of inhibitors. (12)

Recent developments synthesis of anticholesterol drug by biocatalysis routs, Calcium channel blocking drugs, potassium channel openers, antiviral. (10)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1.	Biocatalysis: Fundamentals & Applications	J Andreas S. Bommarius, Bettina R. Riebel	Wiley-VCH, 2004
2.	Biocatalysis and Biodegradation: Microbial Transformation of Organic Compounds	Lawrence Philip Wackett , C. Douglas Hershberger	ASM Press, 2001
3.	Enzymes: Biochemistry, Biotechnology, Clinical Chemistry	T Palmer and P L Bonner .	Horwood Publishing Ltd. (2007), 2nd ed.
4.	Biotransformations in Organic Chemistry	Kurt, Faber	Springer Publications, 2011

Course Code	BIO 852
Course Title	Enzyme Catalyzed Organic Synthesis (Practical)
Type of Course	Core
L T P	0 0 3
Credits	2

Course Assessment Methods

End Semester Assessment (University Exam.) 00

Continuous Assessment (Sessional) 50

Course Prerequisites Enzyme Catalyzed Organic Synthesis (Theory)

Course Objectives The course aims to provide the practical knowledge of Optimization of enzymatic reactions.

Course Outcome

1. Students will be able to perform about enzymatic catalysis reaction conditions.
2. Students will be able to perform about enzymatic catalysis reaction with activators and inhibitors
3. Students will be able to perform about immobilized enzyme application.

SYLLABUS

List of Experiments:

1. To find out enzyme activity and specific enzyme activity.
2. To study the Optimization of enzymatic catalysis reaction conditions.
3. To study the effect of organic solvent on enzyme activity
4. To study the enzymatic catalysis reaction with activators.
5. To study the enzymatic catalysis reaction with inhibitors.
6. To study the Product identification using different analytical technique.
7. To study the cell immobilization and enzyme immobilization of various method.

Course Code	BIO 803
Course Title	Project Management and Entrepreneurship (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4

Course Assessment Methods

End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50

Course Prerequisites	Student should have prior knowledge of Project Management, basics about corporate sector and basic corporate laws.
Course Objectives	1.To appraise the students about entrepreneurship 2. Encourage students to take up self employment/ Entrepreneurship 3. Promote innovation amongst students 4. Make students aware of Project Management and related topics
Course Outcome	1. With limited jobs, this course gives an option to innovative individuals to set up their own venture 2. Turn students into job creators rather than be job seekers. 3. Guide the students in project planning and management 4. Incubate viable projects that may come from students

SYLLABUS

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SECTION-A

Project Formulations and Planning ,Private commercial criteria for project choice, project cycle, feasibility, marketing feasibility (6)

Financing for Projects and financial feasibility (6)

Project Implementation. Brief outline of social cost benefit analysis: rationale. (4)

UNIDO and little Mirrlees approaches, UNIDO-IDCAS manual, shadow prices and conversion factors, applications in India. Planning and scheduling networks (6)

Critical path, PERT model, CPM model, PERT/cost, resource leveling and allocation. (3)

SECTION-B

Entrepreneur- Concept on percent - Functions and clarifications of entrepreneurs - Characteristics of entrepreneur - Nature and importance of ,entrepreneur (6)

Entrepreneur vs. professional manager - Women entrepreneurs. Concept of Entrepreneurship - Entrepreneurship and environment-Policies governing entrepreneurs, entrepreneurial development programmes (6)

Institutions for - entrepreneurship development, entrepreneurship. (2)

Entrepreneurship -Entrepreneurship development in other countries. (2)

Institutions for Entrepreneurial Development - Role of constancy organizations - Role of financial institutions -Bank finance to entrepreneurs Entrepreneurship development: Role of development financial institutions. (4)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1.	Fundamentals of Entrepreneurship and Small business Management	Vasant Desai	Himalya Publishing House
2.	Entrepreneurship	Hisrich,Peters and Shepherd	Tata McGrawHill
3.	UNIDO: Guidelines for Project Evaluation, United Nations	UNIDO	UNIDO
4.	Manual for the preparation of Industrial Feasibility Studies, United Nations		United Nations, 1978.

Course Code	BIO 804
Course Title	Modeling and Simulation of Bioprocesses (Theory)
Type of Course	Core
L T P	4 0 0
Credits	4

Course Assessment Methods

End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50

Course Prerequisites Introductory Bioprocess Engineering and Mathematical Calculation.

Course Objectives

1. To introduce the Basic concepts about kinetic models.
2. To understand the Mathematical representation of bioprocess.
3. To understand the Development of compartment and metabolic pathway models.
4. To introduce the Dynamic simulation of batch, fed-batch, CSTR and transient culture metabolism.
5. To introduce the Numerical optimization.

Course Outcome

1. Students will learn about basic concepts of Kinetic Models.
2. Students will be able to explain about bioprocess design in a various systems solve model equation.
3. Students will be able to explain about dynamic simulation of metabolic pathway models.
4. Students will be able to explain to study the mathematical modeling of batch, Continuous & Fed-Batch Reactors.
5. Students will be able to solve numerical integration techniques for model validation.

SYLLABUS

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SECTION-A

Types of kinetic models. Data smoothing and analysis. (9)

Mathematical representation of bioprocess; parameter estimation; numerical integration techniques; parameter sensitivity analysis; statistical validity. (8)

Discrimination between two models. Physiological state markers and its use in the formulation of a structured model. (6)

SECTION-B

Development of compartment and metabolic pathway models for intracellular state estimation. (8)

Dynamic simulation of batch, fed-batch steady and transient culture metabolism; Numerical optimization of Bioprocesses using Mathematical models. (14)

RECOMMENDED BOOKS

S.No	NAME	AUTHOR(s)	PUBLISHER
1.	Chemical Engineering Dynamics: Modeling and computer Simulation	John Ingham, Irving J. Dunn, Elmar Heinzle & J.E. Prenosil	Wiley-VCH, 2007
2.	Biological Reaction Engineering: Dynamic Modeling Fundamentals with Simulation Examples	Dr. Irving J. Dunn	Wiley-VCH, (2003), 2nd ed.
3.	Bioprocess Engineering Basic Concepts	P.H. M.L.Shuler, F.Kargi .	Phi Learning Pvt Ltd. (2002), 2nd ed.
4.	Bioprocess Engineering Principles	Pauline Doran	Elsevier Science & Technology Books, 1995

Course Code	BIO 854
Course Title	Modeling and Simulation of Bioprocesses (Practical)
Type of Course	Core
L T P	0 0 3
Credits	2
Course Assessment Methods	
End Semester Assessment (University Exam.)	00
Continuous Assessment (Sessional)	50
Course Prerequisites	BIO 804
Course Objectives (CO)	To demonstrate and validate the theoretical concepts.
Course Outcome	The students shall be able to employ numerical methods for the solution of differential models developed for the defined systems.

SYLLABUS

List of Experiments:

Exercises are conducted in the computational lab using C/C++ language/ Excel illustrating the solution to lumped parameter system models.

Course Code	BIO 805
Course Title	Nanobiotechnology (Theory)
Type of Course	Elective
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Basic biotechnology Physics
Course Objectives (CO)	1. The course aims at providing the understanding of basic concepts of nanobiotechnology. 2. The students are made aware of the interface between biology and nanotechnology 3. The students will be introduced to various techniques and methods utilized for fabrication at nanoscale 4. The students will be explained about the applications of nanobiotechnology
Course Outcome	1. Students learn about the basic concepts in nanobiotechnology 2. The students gain insight in the integration of scientific disciplines for approaching the nanoscale dimensions 3. The students learn about application of nanotechnology in healthcare and medicine 4. The students learn about the recent advances in the field of nanobiotechnology

SYLLABUS

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two questions from each section.

SECTION-A

Cell nanostructure interactions: Surface patterning to control the adhesion of cells using nanoscale topography and chemical modifications. (5)

Magnetosomes : Magnetotactic bacteria, magnetite crystals, magneto-aerotaxis, applications. (4)

Nanotherapeutics: Nanoshells, dendrimers , nanoparticles. (5)

Tissue engineering: Significance, Methodology, tissue engineering scaffolds-composition, properties, fabrication, cell seeding and proliferation. (6)

Nanomembranes: Freely suspended nanomembranes. (3)

SECTION B

Bionanodevices: Nanosensors and actuators. (5)

Nanopumps: Fabrication using SOI wafers. (3)

Nonorobots: Developing nanorobots for biomedical application. (4)

Molecular motors: Surface patterning and the control of motility of the actin/myosin motor system. (5)

Engineered nanopores: Classes of nanopores, engineering techniques, potential applications of nanopores. (5)

RECOMMENDED BOOKS

S.No.	NAME	AUTHOR(S)	PUBLISHER
1	Nanobiotechnology:Concepts, Applications and Perspectives.	Edited by: Niemeyer, C.M. and Mirkin, C.A.	Wiley-VCH (2004) 1st edition
2	Bionanotechnology: Lessons from Nature	Goodsell, D.S.	Wiley Liss (2004) 1st edition
3	Nanobiotechnology II: More Concepts and Applications	Edited by: Mirkin, C. A. and Niemeyer, C.M.	Wiley-VCH, (2007) 1st edition
4	Handbook of Nanotechnology	Edited by: Bhushan, B.	Springer Verlag (2010) 3rd edition

Course Code	BIO 805
Course Title	Microbial Biodiversity
Type of Course	Elective
L T P	4 0 0
Credits	4
Course Assessment Methods	
End Semester Assessment (University Exam.)	50
Continuous Assessment (Sessional)	50
Course Prerequisites	Basic concept in bioinformatics and microbiology
Course Objectives (CO)	1. The course aims at introducing students to the diverse microbial communities and their interactions with the environment
Course Outcome	1. Students are able to describe the diversity of various microbial populations 2. Students can use different tools for analyzing microbial diversities and understanding their impact on the environment.

SYLLABUS

Note: *The question paper will be of 50 Marks having 7 questions of equal marks. Students are required to attempt 5 questions in all. First question, covering the whole syllabus and having questions of conceptual nature, will have 10 sub parts and will be compulsory. Rest of the paper will be divided into two parts having three questions each and the Students is required to attempt at least two questions from each section.*

SECTION-A

Microbial biodiversity: definition and introduction, evolution and diversity of microorganisms (7)

Physiological and metabolic diversity of microorganisms (7)

Microbial diversity of major ecosystems (8)

SECTION-B

Biodiversity & role of microorganisms in plants and animal symbiosis (8)

Microbial diversity in extreme environments (9)

Microbial biodiversity, biotechnology and future biodiversity (6)

RECOMMENDED BOOKS

S. No.	NAME	AUTHOR(S)	PUBLISHER
1	Biology Brought to Life (Student Version)	Jo Handelsman	McGraw-Hill, 2002
2	Microbial Diversity: Form and function in Prokaryotes	Oladele Ogunseitan	Blackwell Publishers, 2004
3	Microbial Diversity and Bioprospecting	Alan T. Bull	American Society Microbiology, 2003

Course Name	**:**	**Economics**
Course Code	**:**	**HSS 301a**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Introduction to Economics** Nature of Economics, Economic Thoughts, Economic Activities, Relationship of Economics with other Social Sciences and Engineering	**(5)**
2	**Theory of Consumer Behaviour** Demand: Types, Law of Demand, Determinants of Demand and Change in Demand Elasticity of Demand: Nature, Degrees, Types, Measurement and Factors Affecting Elasticity of Demand and its Application Laws of Consumption: Concept and Applicability of Law of Diminishing Marginal Utility and Law of Equi-Marginal Utility	**(11)**
3	**Theory of Production and Cost** Cost: Types of Costs, Production: Law of Variable Proportion, Returns to Factor and Returns to Scale, Economies and Diseconomies of Scale	**(7)**
4	**Theory of Market** Nature and Relevance of Perfect Competition, Monopoly and Monopolistic Competition	**(7)**
5	**Basic Concepts of Macro Economics** National Income: Concept and Measurement, Determination of Equilibrium of Income Inflation: Concept, Causes and Effect of Inflation, Measures to Control Inflation	**(8)**
6	**Project Presentations**	**(4)**

Course Outcomes:	
1	The students are expected to apply engineering knowledge to maximize profit, satisfaction and welfare.
2	The students are able to identify the forces that affect the economy.
Text Books:	
1	Ahuja H. L., "Modern Economics", S. Chand & Co. Ltd
2	Gupta M. L. & Gupta S. P., "Economics For Engineers", ESS PEE Publications
Reference Books:	
1	Ahuja H. L., "Business Economics", S. Chand & Co. Ltd
2	Jhingan M.L., "Macro Economic Theory", Konark Publisher Pvt. Ltd.
3	Stiglitz J. & Walsh Carl E., "Principles of Microeconomics", W.W. Norton & Company
4	Stiglitz J. & Walsh Carl E., "Principles of Macroeconomics", W.W. Norton & Company
5	Mankiw N Gregory, "Principles of Economics", Cengage Learning
6	Kreps A., "Course in Micro Economics Theory", Prentice Hall
7	Samuelson Paul A. & Nordhaus William D., "Economics", Tata McGraw Hill
8	Gravelle H. & Reiss R., "Microeconomics", Pearson Education
9	Ahuja H. L., "Macro Economics: Theory and Practice", S. Chand & Co. Ltd.

Course Name	**:**	**Introduction to Psychology**
Course Code	**:**	**HSS 301b**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Total No. of Lectures – 42

Course Objectives:		
1	To provide knowledge and understanding about important concepts in Psychology.	
2	To make students learn the application of principles of psychology in working life.	
Lecture wise breakup		**No. of Lectures**
1	Understanding Human Behaviour: Definition, methods, branches and application of psychology for engineers	**(5)**
2	Measuring Human abilities: Intelligence, theories and assessment	**(6)**
3	The individual working life: Personality, approaches and trait theories	**(6)**
4	Psychological problems of everyday life: Stress and coping	**(6)**
5	Work and mental health, workplace spirituality	**(4)**
6	Motivation : the concept and theoretical framework, motivating people at work	**(5)**
7	Group dynamics, Intergroup relations, conflict and negotiation	**(6)**
8	Leadership and Management	**(4)**
Course Outcomes:		
1	The students will learn the causes and dynamics of human behavior.	
2	The students will be able to apply psychological principles to enhance their personal and professional life.	
Text Books:		
1	Ciccarelli, S.K., & Meyer, G.E. Psychology, Pearson, 2007.	
2	Parikh, M., & Gupta, R. Organisational Behaviour. Tata McGraw Hill Education, 2010.	
3	Morgan,C.T., King, R.A., Weiss, J.R., & Schopler, J., Introduction to Psychology . McGraw-Hill, 1986.	

4	Robbins, S.P. Organizational Behavior. Prentice Hall of India, 2003.
5	Luthans,F. Organizational Behavior. McGraw Hill,2010

Course Name	**:**	**Sociology**
Course Code	**:**	**HSS 301c**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Total No. of Lectures – 42

Course Objectives:	
1	To make the students understand the role of theory in social sciences.
2	To explain students how social problems interact and react with the larger society.
3	To make students learn whether the problem is evaluated on the macro or micro perspective and their cause and effect patterns.

Lecture wise breakup		No. of Lectures
1	**Sociology – The Discipline** Sociology as a Science, Impact of Industrial and French Revolution on the Emergence of Sociology, Relevance of Sociology for Engineering	**(3)**
2	**Basic Concepts** Society, Association, Institution, Culture Relativism, Social Structure, Social System, Socialisation, Competition, Conflict, Accommodation, Social Mobility	**(4)**
3	**Pioneering Contributions to Sociology** Seminal Views of Karl Marx, Emile Durkheim, Max Weber, Alwin Toeffler	**(4)**
4	**Evolution of Society** Primitive, Agrarian, Industrial and Post-Industrial, Features of Industrial and Post-Industrial Society, Impact of Automation and Industrialization on Society	**(4)**
5	**Economy and Society** Economic Systems of Simple and Complex Societies, Sociological Dimensions of Economic Life, Market (free) Economy and Controlled (planned) Economy	**(4)**
6	**Industrial Sociology** Nature and Scope of Industrial Sociology, Pre-Conditions and Consequences of	**(4)**

	Industrialization	
7	**Science and Technology** Ethos of Science and Social Responsibility of Science	**(4)**
8	**Social Change** Theories of Change, Factors of Change, Directed Social Change, Social Policy and Social Development, Social Cost Benefit Analysis, Role of Engineers in Development	**(5)**
9	**Understanding Indian Society** Traditional Hindu Social Organization, Caste System, Agrarian Society in India, Social Consequences of Land Reforms and Green Revolution, Working of the Democratic Political System in a Traditional Society, Problem of Education in India, Gender Discrimination, Economic Reforms: Liberalization, Privatization and Globalization, Strategies for Development in India	**(7)**
10	**Social Problems** AIDS, Alcoholism, Drug Addiction, Corruption	**(3)**

Course Outcomes:	
1	The students will be able to identify the function and application of sociology theory in social sciences.
2	The students will be able to understand how social class affects individual life chances.
3	The students will learn about social structure and how it shapes and influences social interactions.
Text Books:	
1	Vardhan Ranjay and Kapila S., "Sociology", New Academic Publishing.
2	Haralambos M., "Sociology: Themes and Perspective", Collins Educational Publications.
Reference Books:	
1	Rao Shankar C.N., "Sociology of Indian Society", Sultan Chand and Co.
2	Bhushan Vidya and Sachdeva D.R., "Introduction to Sociology", Kitab Mahal Publications.
3	Abraham Francis and Morgan J.H., "Sociological Thought", Macmillan India Ltd.
4	Dassgupta Samir and Saha Paulomi, "An Introduction to Sociology", Dorling Kindersley (India)

	Pvt. Ltd.
5	Srinivas M.N., “Social Change and Modern India”, Orient Longman.
6	Amitai Etzioni, “Social Problems” Prentice Hall.
7	Scheneider, “Industrial Sociology”, Tata McGraw Hill.
8	Mandilbaum David, “Society in India”, Popular Publications.
9	Broom L., Selznick P. and Dorrock D., “ Sociology” Harper International Publishing House.