ಬಿ.ಎಂ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರು

(ಸ್ವಾಯತ್ತ ವಿದ್ಯಾ ಸಂಸ್ಥೆ)

ಬುಲ್ ಟೆಂಪಲ್ ರಸ್ತೆ, ಬೆಂಗಳೂರು – ೫೬೦ ೦೧೯

Scheme & Syllabus of
B.E. 3rd to 8th Semester
(Admission year: 2012-15)

BMS COLLEGE OF ENGINEERING, BANGALORE
(Autonomous College under VTU)
Bull temple road, Bangelore-560 019

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: III**

Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
0	9	B	T	3	D	C	B	B	M	Basics of Biomolecules	3	1	0	4	5	50	50	100
0	9	B	T	3	D	C	C	B	G	Cell Biology & Genetics	3	0	1	4	5	50	50	100
0	9	B	T	3	D	C	M	B	G	Microbiology	3	1	1	5	7	50	50	100
0	9	B	T	3	D	C	P	E	T	Process Engg Thermodynamics	3	1	0	4	5	50	50	100
0	9	B	T	3	D	C	U	O	1	Unit operations-1	3	1	0	4	5	50	50	100
0	9	M	A	3	I	C	M	A	T	Engg Maths-III	3	1	0	4	5	50	50	100
0	9	B	T	3	D	M	H	P	H	Human Physiology				0	13 for 1 month only*	50	-	50
Total														**25**	**32****	**350**	**300**	**650**

** Mandatory course, 3 hrs per week (Total of 13 hrs) offered during first one month.*

***Contact hours: 35 hours/week for 1st month, 32 hrs/week for the remaining months.*

L-Lecture Hours/week; T-Tutorial Lecture Hours/week; P-Practical Lecture Hours/week.
CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: IV**

Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
0	9	B	T	4	D	C	B	C	H	Biochemistry	3	1	1	5	7	50	50	100
0	9	B	T	4	D	C	U	O	2	Unit Operations-2	3	1	1	5	7	50	50	100
0	9	B	T	4	D	C	M	A	T	Engg Maths-IV (Biostatistics and Biomodeling)	3	1	0	4	5	50	50	100
0	9	B	T	4	D	C	M	L	B	Molecular Biology	4	0	0	4	5	50	50	100
0	9	B	T	4	D	C	B	C	A	Basics of Computer applications	3	1	0	4	5	50	50	100
0	9	B	T	4	D	C	P	P	C	Process principles and calculations	3	1	0	4	5	50	50	100
Total														**26**	**34**	**300**	**300**	**600**

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week; **P**-Practical Lecture Hours/week.
CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: V**

Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
1	0	B	T	5	D	C	B	A	T	Bioanalytical Techniques	4	0	0	4	4	50	50	100
1	0	B	T	5	D	C	B	I	N	Bioinformatics	3	0	1	4	5	50	50	100
1	0	B	T	5	D	C	E	K	R	Enzyme kinetics & Reaction Engineering	4	0	0	4	4	50	50	100
1	0	B	T	5	D	C	G	E	N	Genetic Engineering	3	1	1	5	7	50	50	100
1	0	B	T	5	D	C	I	M	M	Immunotechnology	4	0	0	4	4	50	50	100
1	0	B	T	5	D	E	E	L	A	Elective-A	4	0	0	4	4	50	50	100
Total														**25**	**28**	**300**	**300**	**600**

Elective A																		
Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
1	0	B	T	5	D	E	B	B	I	Biosensors & Bioinstrumentation	4	0	0	4	4	50	50	100
1	0	B	T	5	D	E	C	T	B	Computational Biology	4	0	0	4	4	50	50	100
1	0	B	T	5	D	E	I	B	T	Industrial Biotechnology	4	0	0	4	4	50	50	100
1	0	B	T	5	D	E	M	G	T	Management & Entrepreneurship	4	0	0	4	4	50	50	100

L-Lecture Hours/week; T-Tutorial Lecture Hours/week; P-Practical Lecture hours/week.
CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: VI**

Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
1	0	B	T	6	D	C	E	Q	D	Bioprocess Equipment Design and Drawing	3	1	0	4	5	50	50	100
1	0	B	T	6	D	C	E	N	T	Enzyme Technology	3	1	1	5	7	50	50	100
1	0	B	T	6	D	C	G	A	P	Genomics & Proteomics	3	0	0	3	3	50	50	100
1	0	B	T	6	D	C	P	B	T	Pharmaceutical Biotechnology	3	0	0	3	3	50	50	100
1	0	B	T	6	D	C	P	C	A	Process control & Automation	3	1	1	5	7	50	50	100
1	0	B	T	6	D	E	E	L	B	Elective-B	4	0	0	4	4	50	50	100
Total														**24**	**29**	**300**	**300**	**600**

Elective B																		
Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
1	0	B	T	6	D	E	A	B	T	Animal BT	4	0	0	4	4	50	50	100
1	0	B	T	6	D	E	M	T	E	Metabolic Engineering	4	0	0	4	4	50	50	100
1	0	B	T	6	D	E	P	B	T	Plant Biotechnology	4	0	0	4	4	50	50	100
1	0	B	T	6	D	E	R	M	D	Research Methodology	4	0	0	4	4	50	50	100

L-Lecture Hours/week; T-Tutorial Lecture Hours/week; P-Practical Lecture Hours/week.
CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: VII**

Course Code	Course Title	Credit Hours /Week				Contact Hrs /week	Marks		
		L	T	P	Total		CIE	SEE	Total
11BTI7OICELC1	Institutional Elective-I	4	0	0	4	4	50	50	100
11BTI7DCUPT	Upstream Process Technology	3	1	1	5	7	50	50	100
11BTI7DCDSP	Fermentation Technology and Downstream processing	3	1	1	5	7	50	50	100
11BTI7DCPPE	Process Plant Design & Economics	3	0	0	3	3	50	50	100
11BTI7DCSEM	Seminar	0	0	2	2	2	50	50	100
11BTI7DCMPR	Mini-Project	0	0	2	2	2	50	50	100
11BTI7DEELC	Elective C	3	0	0	3	3	50	50	100
Total					**24**	**28**	**350**	**350**	**700**

Elective C															
Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
11BTI7DEHDC										Health Diagnostics & Clinical Biotechnology	3	0	0	3	3	50	50	100
11BTI7DEMAT										Microarray technology	3	0	0	3	3	50	50	100
11BTI7DEIPR										Intellectual Property Rights	3	0	0	3	3	50	50	100
11BTI7DEDBT										Dairy Bio technology	3	0	0	3	3	50	50	100
11BTI7DEMBT										Microbial BT	3	0	0	3	3	50	50	100

L-Lecture Hours/week; T-Tutorial Lecture Hours/week; P-Practical Lecture Hours/week.
CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL Program: BE Semester: VIII

Course Code										Course Title	Credit Hours/Week				Contact Hrs/ week	Marks		
											L	T	P	Total		CIE	SEE	Total
1	1	B	T	8	O	I	E	L	2	Institutional Elective-II	4	0	0	4	4	50	50	100
1	1	B	T	8	D	C	B	I	S	Bioethics & Biosafety	3	0	0	3	3	50	50	100
1	1	B	T	8	D	C	P	R	W	Project work	0	0	16	16	16	50	50	100
1	1	B	T	8	D	E	E	L	D	Elective D	3	0	0	3	3	50	50	100
Total														**26**	**26**	**200**	**200**	**400**

Elective D																		
Course Code										Course Title	Credit Hours/Week				Contact Hrs/wk	Marks		
											L	T	P	Total		CIE	SEE	Total
1	1	B	T	8	D	E	F	R	S	Forensic science	3	0	0	3	3	50	50	100
1	1	B	T	8	D	E	T	S	E	Tissue engineering	3	0	0	3	3	50	50	100
1	1	B	T	8	D	E	B	M	T	Bio Materials	3	0	0	3	3	50	50	100
1	1	B	T	8	D	E	I	D	D	Protein & Insilco drug design	3	0	0	3	3	50	50	100
1	1	B	T	8	D	E	N	B	T	Nano biotechnology	3	0	0	3	3	50	50	100
1	1	B	T	8	D	E	F	V	Q	Facilitation, Validation and QC	3	0	0	3	3	50	50	100

L-Lecture Hours/week; T-Tutorial Lecture Hours/week; P-Practical Lecture Hours/week.
CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

Course Title	BASICS OF BIOMOLECULES										Credits	4		
Course Code	0	9	B	T	3	D	C	B	B	M	L-T-P	3	1	0

Pre-requisites:
Knowledge of chemistry, Mathematics and Basics of Biology.

UNIT 1 **[9L+3T]**

ORGANIC REACTIONS

Principles of chemical bonding- atomic orbitals and hybridization, valence bond theory, VSRPR theory, Reaction mechanisms-fundamental aspects(electron displacement effects), Carbonium ions and their reactions, Carbanions and their reactions, Electrophilic and nucleophilic reagents and their role, Types of Reaction mechanisms, Energy requirement of a reaction, Applications of general mechanistic concepts-Electrophilic and nucleophilic. Substitution reactions with one example, Elimination reactions, Addition reactions, Rearrangement reactions, polymerization reactions, Condensation reactions, Reduction and oxidation reactions, Reaction rates, order and molecularity of reactions.

UNIT 2 **[6L+2T]**

BASIC CONCEPTS

Solution chemistry- solvents, solutes, concentration of solutions, structure and properties of water, pH and buffers. Non-covalent interactions- hydrogen bonds, van der Waals forces, electrostatic and hydrophobic interactions. Stereochemistry-importance of stereochemistry, geometric and optical isomerism, configuration and conformation, chirality, relation between chirality and optical activity, representation of chiral structure by Fischer formulas, Absolute and relative configuration, D & L and R and S nomenclature, Nomenclature of chemical compounds.

UNIT 3 **[9L+2T]**

STRUCTURE OF CARBOHYDRATE AND LIPIDS

Carbohydrates-Introduction, sources, classification into mono, oligo and polysaccharides, Classification of monosaccharides based on no. of carbon atoms and functional groups, reactions of carbohydrates, Isomerism of carbohydrates, Fischer and Haworth formulas, pyranose and furonose structures, anomers and epimers, chair and boat conformations, structure and function of simple sugars-mono and disaccharides, homo and hetero polysaccharides, sugar derivatives, glycoproteins.

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

UNIT 4 **[10L+3T]**

STRUCTURE OF AMINO ACIDS AND PROTEINS

Introduction, classification, optical isomerism, chemical properties, acid-base properties-polyionic nature, zwitter ions, pK^{a} and pI, peptide bond formation and properties, biologically important peptides (oxytocin, vasopressin, bradykinin and glutathione), classification of proteins, levels of protein structure, determination of primary structure (sequencing strategies), conformational analysis and forces that

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

UNIT 5 **[6L+2T]**

STRUCTURE OF NUCLEIC ACIDS

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

Course Outcomes:

1. Explain the principles of chemical bonding and identify the different reaction types and mechanisms involved in organic reactions
2. Solve problems based on the concepts of solution chemistry and illustrate the different structural configurations of organic molecules.
3. Explain the physiochemical properties and structural confirmations of biomolecules,
4. Comprehend the importance of biomolecules in biological systems.

TEXT BOOKS

1. **Lehninger Principles of Biochemistry** by David L. Nelson and Michael M. Cox, W.H. Freeman and company (5th Ed.).
2. **Organic Chemistry** by Morison and Boyd, Prentice Hall (6th Ed.).
3. **Biophysical Chemistry** by Upadhyay, Upadhyay and Nath, Himalaya Publishing House, (93rd Ed.)

REFERENCE BOOKS

1. **Biochemistry** by Voet and Voet, Wiley New York.
2. **Principles of Biochemistry** by Lubert Stryer Freeman (Int. Ed.).2
3. **Principles of Nucleic Acid Structure** by Sanger, Springer Verlag.
4. **Principles of Protein Structure** by G Schulz and R H Schrimer, Springer Verlag.
5. **Biophysical Chemistry** by Canter R and Schimmel P R, WH Freeman, (10th Ed.).

Course Title	CELL BIOLOGY & GENETICS										Credits	4		
Course Code	0	9	B	T	3	D	C	C	B	G	L-T-P	3	0	1

Pre-requisites:
Knowledge of basic biology

PART-A : CELL BIOLOGY AND GENETICS THEORY

UNIT 1

General organization of Cells: Eukaryotic (Plant and Animal cell) and Prokaryotic cells (Bacterial).

1) Cell membranes; composition of membranes and models of membrane organization, membrane proteins, Diffusion and transport across membranes, Ionophores, Membrane Potentials. **[03 hrs]**

2) Cellular organelles: Nucleus, Mitochondria, Chloroplasts, Ribosomes, Golgi bodies, Lysosomes, Endoplasmic Reticulum, Peroxisomes, and Vacuoles. **[04 hrs]**

UNIT 2

1) Cytoskeleton- Structure organization and function of cytoskeleton (microtubules, intermediate proteins, microfilaments) and associated proteins. **[02 hrs]**

2) Cell in Social context; Cell to cell integration, Cell locomotion (Amoeboid, Flagellar, Cilliar). Exo and endocytosis. Structure and function of muscle and nerve cell. **[04 hrs]**

3) Cell division: Stages of cell cycle. Mitosis and Meiosis. Controle of cell division and its significance. **[02 hrs]**

4) Cell-cell Communication: Types of cell communications (contact, autocrine, endocrine, paracrine and synaptic). Classification, Structure and mechanism of Action of receptors. Plant growth factors and hormones - Auxins, Gibberlins, Cytokinins and Ethylene. **[04 hrs]**

UNIT 3

1. Introduction to Genetics

Introduction: Introduction to nuclear and extranuclear genomes, their origin, genetic relevance and their functions, experiments on proof of DNA and RNA as genetic material, Chromosomal theory of inheritance.

Molecular genetics: Genetic basis of replication, transcription, translation.

Great Geneticist: Geneticists and their discoveries. **[03 hrs]**

2 .Mendelian genetics

Introduction to various terminologies, Mono, di and trihybrid crosses, Experiments with pea and bees, Punnett square, forked line, probability method, principles and laws. Related numerical problems.

3.Post Mendelian genetics

Various gene interactions epistasis, complete and incomplete dominance, complementary and supplementary gene interaction, multiple allele. Related numerical problems. **[03 hrs]**

UNIT 4

Prokaryotics genetics with reference to Bacteria

Introduction to prokaryote genomes, their packing, plasmids, conjugation, transformation, transduction, mutations. **[02 hrs]**

Eukaryotics genetics

1) Fungal and Plant genetics: Nuclear and extra nuclear genomes, structure, functions, their evolution. Chromosome structure and organization, packing, cytoplasmic inheritance, sex determination. Linkage and crossing over, mapping, mutations. Genome project. Related numerical problems. **[02 hrs]**

2)Fly and Amphibian genetics: Chromosome structure and organization, polytene chromosome, lamp brush chromosome, sex determination, Linkage and crossing over, mapping, mutations, Genome project. Related numerical problems. **[02 hrs]**

UNIT 5

Human genetics: Chromosome structure and organization, sex determination, Linkage and crossing over, mapping. Pedigree analysis, Chromosomal aberrations, sex linked and autosomal disorders, gene defects and disorders, genome project. Related numerical problems. **[02 hrs]**

Population genetics

Coalescent theory , Dual inheritance theory, inbreeding and heterosis, selection, mutation, Founders effect and genetic drift, Gene and allele frequency, Hardy Weinberg law and variations, Speciation and evolution, QTL and mapping, Eugenics. Related numerical problems. **[04 hrs]**

Course Outcomes:

1. Distinguish prokaryotic and Eukaryotic cell types and describe structure and function of organelles.
2. Describe stages of cell division, modes of cell communication and organization of genomes.
3. Understand the concepts of mendelian and non-mendelian interactions and apply to solve problems on inheritance.
4. Analyze and interpret genetical data of given population.
5. Demonstrate ability to isolate and identify various cells and cell cycle as well interpret genetical data.

TEXT BOOKS

1. **Genetics** by Monroe W Strickberger Macmillan pub.
2. **Molecular Biology of the Cell**, Bruce Alberts et al.garland Science Pub. (4^{th} ed.).
3. **Principles of Genetics** by Gardener, Simmons and Snustad.J.Wiley & sons (Asia ed.).
4. **Cell and Molecular Biology** by Gerald Karp. John Wiley & sons

REFERENCE BOOKS

1. **Molecular aspects of Cell Biology** by Garret and Gusham. Harcourt College Pub.
2. **Genetics** by Good Enough.Sounders College pub (3 Ed.).

3. **Genes and Genomes** by M Singer and P Berg Blackwell, Blackwell Science Ltd.
4. **CeIl Biology** by J.W.Kimball, Addison-Welsey Pub.92nd edn.).
5. **Molecular Cell Biology** by DarneIl and Baltimore et al Freeman & Co. Pub.
6. **Cell Biology** Gupta MI and Jahangir MI, Agro bios (India).
7. **Cell and Molecular Biology** by Lodish. Freeman publ.
8. **Genetics** by Cooper.Academic press.

PART-B : CELL BIOLOGY AND GENETICS-LAB (2 hrs/week)

1. Study of mitosis from onion root tips.
2. Study of meiosis from testis/onion flower buds.
3. Isolation of protoplast and Fusion of Protoplast.
4. Isolation of chloroplast from plant tissue.
5. Polytene chromosome from Drosophila.
6. Human karyotyping.
7. Analysis of Barr body.
8. Pedigree analysis.
9. Lymphocyte separation from blood and counting.
10. Differential staining of blood cells.

Course Title	MICRO BIOLOGY										Credits	5		
Course Code	0	9	B	T	3	D	C	M	B	G	L-T-P	3	1	1

Pre-requisites:
Knowledge of basic biology

PART A : THEORY +TUTORIAL

UNIT 1 **[5L+2T]**

INTRODUCTION

The Scope of Microbiology, History of Microbiology (origin, contributions of Anton van Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner and Joseph Lister), Microbial diversity
And Taxonomy (Numerical, Phylogenetic and Molecular approaches), Types of Microorganisms.

MICROSCOPY

Bright-Field Microscopy, Dark-Field Microscopy, Phase-Contrast Microscopy, Fluorescence Microscopy, Electron Microscopy.

UNIT 2 **[9L+2T]**

STUDY OF MICROORGANISMS

The morphology and ultra structure of Bacteria, Culturing of Bacteria, Nutritional requirements, Culture Media and types, Bacterial Growth, Factors affecting growth, Measurement of growth,Pure culture and cultural characteristics. Reproduction, morphology and classification of fungi and mode of reproduction in Yeast. Morphology and classification of Viruses and mode of reproduction in T4 B.phage, TMV and HIV.
Microbial Metabolism- aerobic and anaerobic growth, Metabolic pathways (Glycolysis, HMP, ED pathway, alcohol and acid fermentation-homo & heterolactic,mixed acid), Primary and secondary Metabolites-brief mention with examples and applications.

UNIT 3 **[8L+2T]**

MICROBIAL TECHNIQUES

Pure culture Techniques: (streak-plate, spread plate, pour plate), Microbial staining: Principle of Staining, types of stains, Staining techniques (Simple staining, differential staining-Gram staining, Endospore, Capsule and Flagella Staining) Enumeration of Microorganisms :(DMC, SPC, Membrane filtration method, Electronic counter) Characterization: Biochemical tests (Introduction to enzymes and Biochemical reactions, principle, procedure and observations of test for starch hydrolysis, Gelatin liquefaction, fermentation of carbohydrates. Oxidase, Catalase, IMViCtest.

UNIT 4 **[6L+2T]**

CONTROL OF MICROORGANISMS

Physical methods (heat, filtration, radiation), Chemical methods (Phenol & Phenolic compounds, Alcohols, Halogens, Dyes, Detergents, Aldehydes, Heavy metals, etc), Antibiotics and other chemotherapeutic agents.

STUDY OF MICROBIAL DISEASES **[6 L+2T]**

Causative agent, Pathogenesis, Symptoms, Advanced diagnostic techniques and treatment of Bacterial diseases: Tuberculosis, Leprosy, Typhoid, Diarrhea, Pneumonia.Viral diseases: AIDS, Hepatitis, Rabies, Protozoan diseases: Ameobiosis, Malaria.Fungal diseases: Candidiasis

UNIT 5 **[6L+2T]**

APPLIED MICROBIOLOGY

Microbes in Agriculture: Recycling of Nutrients, Biofertilizers, Biopesticides, Aquatic Microbiology, Microbes in Industrial fermentation: Aerobic and anaerobic fermentation (with examples). Microbes in Food industry: As food contaminants, Food processing, Microbes as food (Yeast and SCP). Microbes in Environment: Bioremediation (Pollutant degradation, Sewage and Effluent treatment. Bioleaching and Biological indicators).

Course Outcomes:

1. a) Understand the working principle of various types of microscopes.
   b) Select an appropriate microscopic technique for identification of microbes.
2. a) Understand the structure and biology of microbial organisms
   b) Describe the various metabolic pathways and industrial applications of microbes.
   c) Measure microbial growth using suitable analytical technique.
3. Conduct experiments and draw inferences for isolation and characterization of desired microorganism.
4. a) Graduates will understand pathogenesis diagnosis & treatment of microbial diseases.
   b) Explain sterilization techniques for control measure in biotechnological Engineering practices.

TEXT BOOKS

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

REFERENCE BOOKS

1. **Fundamental principles of Bacteriology** by Paule proe
2. **Fundamentals of Biotechnology** by Ajit Verma.
3. **General Microbiology** by Stanier, John Ingraham and Mark wheelis, Mac- Millan Pub.
4. **Microbiology an Introduction** by Tortora, Finke and Case. Pearson education.
5. **Biology of Microorganisms** by Brock
6. **Biotechnological Applications of Microbes**. Ik Intl- Pub House

PART B: MICROBIOLOGY LAB (2 hrs/week)

1. Laboratory rules, General instruments (Microscope, Autoclave, Hot air oven, Incubator, LAF) and other requirements in Microbiology laboratory.
2. Media preparation, plugging and sterilization. (NA/NB, PDA/PDB, MRBA, EMB agar, Blood agar, Mac Conkey agar).
3. Pure culture techniques (serial dilution, pour plate, spread plate and streak plate methods).
4. Isolation and characterization of Microbes from soil, Water and Air.
5. Examination of microorganisms from hand, nail, tooth scrapings and rotten fruits and vegetables.

6. Enumeration of microbes (Bacteria and Fungi) by DMC, SPC and Turbidometry.
7. Examination of living microbes by TWM technique, Hanging drop technique (Bacteria and Protozoa).
8. Staining techniques (Simple staining, Gram staining and endospore staining for Bacteria and Lacto phenol cotton blue staining for fungi.
9. Biochemical Tests (Starch hydrolysis, Gelatin liquefaction, MPN, Catalase and IMViC tests)
10. Measurement of growth and factors influencing growth of microbes (Determination by dry weight, effect of TDT and TDP, size determination by Micrometry).
11. Antibiotic susceptibility testing of bacteria.
12. Alcoholic and mixed acid fermentation.

REFERENCE BOOKS

1. **Experiments in Microbiology, Plant pathology and Biotechnology** by K.R.Aneja (4^{th} ed.)
2. **General Microbiology** by Stainer, Ingraham and Wheeler Mac-Milian Pub.
3. **Microbiology** by Pelczar, Chan and Krig Tata Mc Graw Hill
4. **Introductory Microbiology** by Heritage (Cambridge Low Price ed.).
5. **Industrial Microbiology** by Prescott and Dunn,CBS Pub. (4^{th} Ed.).
6. **A Text Book of Microbiology** by P. Chakraborty,New Central Book Agency, 2005.
7. **Fundamentals of Microbiology and Immunology** by Ajit Kumar Bannerjee 2006.
8. **Lab Math** by Dany Spencer Adams, IK Intl. Pub. House (2004).
9. **Lab Ref** by Jaine Roskams & Linda Rodgers, IK Intl. Pub. House.

Course Title	PROCESS ENGG THERMODYNAMICS										Credits	4		
Course Code	0	9	B	T	3	D	C	P	E	T	L-T-P	3	1	0

Pre-requisites:
Knowledge of Engineering Physics, Chemistry and Mathematics.

UNIT 1 **[9L+2T]**

BASIC CONCEPTS AND LAWS OF THERMODYNAMICS

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

UNIT 2 **[8L+2T]**

PVT BEHAVIOUR AND COMPRESSIBILITY CHARTS

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

UNIT 3 **[9L+2T]**

PROPERTIES OF PURE FLUIDS AND PROPERTIES OF SOLUTIONS

Reference properties, Energy properties, Derived properties, Work function, Gibbs free energy, Relationships among thermodynamic properties: Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy & heat capacity relations, Modified equations for internal energy (U) & enthalpy (H), Effect of temperature on U, H & entropy (S), relationships between C_p and C_v, Gibbs-Helmholtz equation, Fugacity, fugacity coefficient, effect of temperature & pressure on fugacity, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: Effect of temperature and pressure on activity, Partial molar properties, chemical potential, fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, activity coefficients, Gibbs-Duhem equation, Property changes of mixing, Excess properties.

UNIT 4 **[8L+2T]**

PHASE EQUILIBRIA

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

UNIT 5 **[8L+2T]**

BIOCHEMICAL ENERGETICS

Coupled reactions & energy rise compounds, Reaction stoichiometry, Criteria of biochemical reaction equilibrium, Equilibrium constant & standard free energy change, Effect of temperature, Pressure on equilibrium constants & Other factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous bioreaction equilibria, Phase rule for reacting systems.

Course Outcomes:

1. Identify the various types of systems, processes and to solve engineering problems using laws of thermodynamics.
2. A. Comprehend the P-V-T behaviour of pure fluids and solve related problems. B. Understand heat effects in chemical reactions and solve related problems.
3. Solve problems related to properties of pure fluids and solutions.
4. Apply the concept of phase equilibria, reaction equilibria and energetics in the biochemical engineering problems.

TEXT BOOKS

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

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

REFERENCE BOOKS

1. **Biochemical Calculations** by Segel I. H., John Wiley & Sons Inc. (2^{nd} Ed.), 1976.
2. **Chemical Engineering Thermodynamics** by Rao Y. V. C., New Age International.
3. **Engineering Thermodynamics** by Jones J. B., Hawkins. , John Wiley & Sons Inc.
4. **Chemical, Biochemical and Engineering Thermodynamics** by Sandler S. I., John Wiley & Sons Inc. (4th Ed.)

Course Title	UNIT OPERATIONS-1										Credits	4		
Course Code	0	9	B	T	3	D	C	U	0	1	L-T-P	3	1	0

Pre-requisites:
Knowledge of Engineering Physics and Mathematics

UNIT 1 **[8L+2T]**
DIMENSIONAL ANALYSIS
Units and Dimensions: Fundamental and derived units, Conversion. Dimensional consistency of equations. Dimensionless groups and constants. Derived Units, Dimensionless numbers, and constants, Dimensional analysis: Rayleigh's method, Buckingham's π method.

UNIT 2 **[8L+2T]**
FLUID FLOW PHENOMENA
Fluid definition and Classification (Newtonian and Non-Newtonian), Pressure measurement, Types of flow-laminar & turbulent, Reynolds Stress, Eddy Viscosity, Flow in Boundary Layers, Reynolds number, Boundary Layer Separation.

UNIT 3 **[9L+3T]**
FLOW OF INCOMPRESSIBLE FLUIDS
Fluid flow – Continuity and Bernoulli equations, Flow through circular and non circular conduits- Hagen Poiseuille equation, Flow through stagnant fluids –Settling and sedimentation Pressure drop through packed bed-Ergun's equations

UNIT 4 **[7L+2T]**
FLOW MEASUREMENTS
Flow measurements - Orifice meter, Venturimeter, Rota meter, Performance & Characteristics of Pumps; Centrifugal & Reciprocating pumps, Energy calculations Fans, Compressors, Blowers.

UNIT 5 **[9L+2T]**
MECHANICAL OPERATIONS
Size reduction, Sieve analysis, Screen effectiveness, capacity, Sedimentation – Equipments, Mixing – Types of mixers, power number, power consumption in mixing operation, Filtration - constant rate and constant pressure filtration, Filtration equipments, Centrifugal separations, Centrifuges.

Course Outcomes:
1. Identify the various types of fluids, their characteristics and applications.
2. Analyze the fluid flow under various regimes, select suitable transport and metering mechanism.
3. Comprehend the concepts of size reduction, filtration, sedimentation and mixing in upstream and downstream processes.
4. Formulate, analyze and solve engineering problems involving fluid mechanics and mechanical operations.

TEXT BOOK

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

REFERENCE BOOK

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

Course Title	ENGINEERING MATHS III										Credits	4		
Course Code	0	9	M	A	3	I	C	M	A	T	L-T-P	3	1	0

39L + 13T

Common to all branches except CSE/ISE

Pre-requisites: Knowledge of Engineering Maths-I and II

UNIT 1 **[7L+2T]**

FOURIER SERIES

Infinite series, convergence and divergence of infinite series of positive terms, power series, periodic function, Dirichlet's conditions, statement of Fourier Theorem, Fourier series of periodic function of period 2π and arbitrary period, half range Fourier series, complex form of Fourier series, practical harmonic analysis.

UNIT 2 **[7L+2T]**

FOURIER TRANSFORMS

Infinite Fourier transform, Fourier Sine and Cosine transforms, properties, Inverse transforms, Convolution theorem (statement only), Parseval's identities for Fourier transform. Fourier transforms of the derivatives of a function

UNIT 3

PARTIAL DIFFERENTIAL EQUATIONS

Formation of Partial differential equations-elimination of arbitrary constants, elimination of arbitrary functions. Equations of first order- The linear equation $P\,p + Q\,q = R$ **(**Lagrange's partial differential equation). Method of separation of variables. **[5L+2T]**

APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Derivation of one-dimensional heat equation, wave equation, various possible solutions of these by the method of separation of variables, D'Alembert's solution of wave equation. **[4L+1T]**

UNIT 4

NUMERICAL METHODS - 1

Finite Differences and interpolation: Forward differences, Backward differences.

Interpolation: Newton-Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Newton's general interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical differentiation: Numerical differentiation using Newton-Gregory forward and backward interpolation formula. **[4L+2T]**

Numerical integration**:** Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, Weddle's rule.

Solution of algebraic and transcendental equations: Ramanujan's method, Newton-Raphson method, deductions. Numerical solution of ordinary differential equations: Euler's modified method, Runge-Kutta method of fourth order. **[4L+1T]**

UNIT 5 **[4L+2T]**

Z- TRANSFORM

Definition, Properties, Transforms of standard functions, Inverse transforms.

APPLICATIONS OF Z -TRANSFORMS

Solution of difference equations using Z- transforms.

CALCULUS OF VARIATIONS

Variation of function and functional, Euler's equation, variational problem.

APPLICATIONS OF CALCULUS OF VARIATIONS

Geodesics, minimal surface of revolution, hanging chain, Brachistochrone problem. **[4L+1T]**

Course Outcomes:

1. Express given functions to form Fourier series
2. Demonstrate an understanding of Fourier transforms techniques
3. Employ analytical techniques to solve partial differential equations with appropriate boundary conditions
4. Compute interpolating polynomials, derivatives, integrals for a given function from a given data
5. Apply Z- transforms techniques to solve difference equations Use calculus of variations to find the extremal of a functional

TEXT BOOKS

1. **Higher Engineering Mathematics** by B.S. Grewal, 40th edition, 2007, Khanna Publishers.
2. **Advanced Engineering Mathematics** by Erwin Kreyszig, 8th edition, 2007, Wiley-India
3. **Introductory methods of Numerical Analysis** by S. S. Sastry, 3rd edition, 1999, Prentice-Hall of India.

REFERENCE BOOKS

1. **Advanced Modern Engineering Mathematics** by Glyn James, 3rd edition, 2004, Pearson Education.
2. **Higher Engineering Mathematics** by B.V. Ramana, 2007, Tata Mc. Graw Hill.
3. **Advanced Engineering Mathematics** by P. V. O'Neil, 5th Indian reprint, 2009, Cengage learning India Pvt. Ltd.

QUESTION PAPER PATTERN

1. Each unit consists of one full question.
2. Each full question consists of three or four subdivisions.
3. Five full questions to be answered.
4. Internal Choice in Unit 3 and Unit 5

Course Title	HUMAN PHYSIOLOGY**										Credits	0
Course Code	0	9	B	T	3	D	M	H	P	H		

*** Mandatory course, 3 hrs per week (Total of 13 hrs) offered during first one month*

Pre-requisites:
Knowledge of Basic Biology

UNIT 1
CO-ORDINATED FUNCTIONS:
Introduction – scope and fields of Physiology

a) Digestion and absorption of food: - Structure and function of different components of digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of various enzymes and hormones involved in digestive process.
b) Circulation:- Composition of blood and coagulation of blood. Blood groups- ABO and Rhesus system. Composition and function of lymph and lymphatic System. Heart structure and function
c) Respiration: components of respiratory system , gaseous exchange
d) Excretory system:-: Overall design of urinary system: Kidney structure, selective reabsorption, active and passive transport of various substances and secretion.
e) Reproduction: - Male and female reproductive systems. **[08 hrs]**

UNIT 2
CONTROL SYSTEMS

a) Neural control mechanisms: - Brief outline of nervous system-brain, spinal cord, nerve fibres, and synapses, chemical and electrical synapses, nerve impulses, action potential and neurotransmitters.
b) Sensory organs: - outline of various sensory organs and their functions.
c) Skeletal and Muscle system: - kinds of muscles and mechanism of muscle contraction.
d) Hormonal control mechanisms: organization of endocrine and exocrine systems. Classification of hormones. **[05 hrs]**

Course Outcomes:
1. Comprehend coordinated functions of various organs in human.
2. Describe the control mechanisms in human body.

TEXT BOOKS
1. **Harper's Physiological Biochemistry** by Harper et al.Mc Graw-Hill Medical 2nd Edition
2. **Text Book of Medical Physiology** by A.R.Guyton,John E Hall,W.B.Saunders Co. 2nd Edition

REFERENCE BOOKS
1. **Textbook of Human Physiology** by Sharadha Subramanian, K.M.Kutty,H.D.Singh,S.Chand and Co.
2. **The living body** –**A text in Human Physiology** by Best and Taylor,Chapman and Hall.

Course Title	BIOCHEMISTRY										Credits	5		
Course Code	0	9	B	T	4	D	C	B	C	H	L-T-P	3	1	1

Pre-requisites:
Knowledge of organic chemistry, Basics of Biomolecules and Cell Biology and Genetics.

PART A: THEORY+ TUTORIAL

UNIT 1 **[6L+2T]**

PRINCIPLES OF BIOENERGETICS

Energy concepts-different forms of energy, Energy conservation/transduction, Energy flow cycle, Energy batteries, High energy compounds, Structure and properties of ATP, Thermodynamic concepts, Free energy change and equilibrium constant, Coupling reactions, Free energy and oxidation –reduction potential, Simple problems.

UNIT 2 **[10L+2T]**

CARBOHYDRATE METABOLISM

Introduction, Glycolytic pathway and its regulation, Gluconeogenesis and its regulation, Regulation of blood glucose level, Hyperglycemia and hypoglycemia, Diabetes Mellitus-biochemical and clinical changes associated with IDDM and NIDDM,GTT, Degradation, synthesis and regulation of glycogen, Glycogen storage disorders, Hexose interconversions, Fructose and lactose intolerance, Fructosuria, Galactosemia, TCA cycle and its regulation, Amphibolic and anaplerotic reactions, HMP pathway, Glyoxylate pathway, Structure and functions of electron carriers of ETC, Respiration and ATP formation in mitochondria, Electron transport chain, Oxidative phosphorylation, Energetics of Electron transport chain, Malate-Aspartateshuttle system.

UNIT 3 **[6L+2T]**

PHOTOSYNTHESIS

Introduction, Bacterial photosynthesis, Chloroplast/thylokoid structure, Photosynthetic apparatus, Photosynthetic reaction centre, Hill reaction, Light reaction, Cyclic and non-cyclic photophosphorylation, CO_2 assimilation reaction, C_4 and CAM pathways, Photorespiration.

UNIT 4 **[9L+2T]**

LIPID METABOLISM

Digestion, mobilization and transport of fats, Oxidation of even numbered fatty acids, Oxidation of unsaturated fatty acids, Energetics of β-oxidation, Formation of ketone bodies and their oxidation, Biosynthesis of fatty acid-fatty acid synthase complex, biosynthesis of palmitate and its energetics, Biosynthesis of triacylglycerols, phospholipids and sphingolipids, Biosynthesis of cholesterol and its regulation.

UNIT 5 **[10L+3T]**

NITROGEN METABOLISM

Overview of amino acid catabolism in mammals - transamination (mechanism of transamination involving PLP to be included), oxidative deamination, Nitrogen excretion and urea cycle, Disorders of amino acid

metabolism-phenylketonuria, alkaptonuria, maple syrup disease and albinism, Biosynthesis of amino acids of oxaloacetate family.
Biosynthesis of nucleotides-De novo purine nucleotide synthesis (AMP and GMP), De novo pyrimidine nucleotide synthesis (UTP, CTP and dTTP), Regulation of biosynthesis of purine and pyrimidine nucleotides, Recycling of purine and pyrimidine nucleotides by salvage pathway, Catabolism of purine and pyrimidine nucleotides, Genetic disorders associated purine and pyrimidine nucleotides (Lesch-Nyhan syndrome and Gout).

Course Outcomes:

1. Understand the principles governing bioenergetics and the role of high energy compounds in living systems.
2. Understand the concepts of thermodynamics of electron transfer and redox reactions in aerobes.
3. Describe the steps involved in metabolic pathways in living systems.
4. Understand the importance of homeostatsis of metabolic pathways in health and disease.
5. Understand the mechanism of energy generation in living systems .PO1M
6. Design , conduct experiments and interpret data related to estimation and analysis of biomolecules

TEXT BOOKS

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

REFERENCE BOOKS

1. **Biochemistry** by Voet and Voet ,Wiley New York
2. **Biochemistry and Molecular Biology** by Elliot and William H, Oxford publishers.
3. **Biochemistry** by Thomas M. Devlin, Wiley-Liss, (5th ed.)
4. **Biochemistry** by Mathews, Vanholde and Arhen, Pearson Education
5. **Biochemistry** by Garett and Grisham ,Thompson Learning
6. **Bioenergetics** by David.G.Nicolls and Styart J. Ferquson, Academic Press, Elsevier.

PART B: BIOCHEMISTRY LAB (2hrs/week)

1. Volume/weight measurements, Concentration units, pH measurements, Preparation of buffers.
2. Qualitative tests for carbohydrates and lipids.
3. Qualitative tests for amino acids and proteins.
4. Estimation of blood sugar by Folin-wu method.
5. Estimation of blood sugar by O-toluidine method.
6. Estimation of inorganic phosphate by Fiske-Subbarow method.
7. Estimation of amino acid by ninhydrin method.
8. Estimation of urea by diacetyl monooxime method.
9. Estimation of protein by Lowry method.
10. Estimation of cholesterol by Zak and Henly's method.
11. Determination of iodine value of lipids.
12. Determination of saponification value of lipids.
13. Estimation of blood sugar by Hegde and Johnson method.
14. Titration of amino acids by acids and bases.

REFERENCE BOOKS

1. **Lab manual** by Faculty
2. **An introduction to Practical Biochemistry** by David T. Plummer, Tata Mc Graw Hill.(3rd Ed.))
3. **Experimental Biochemistry** by Beedu Sashidhar Rao and Vijay Deshpande, I.K. International Pvt. Ltd.

Course Title	UNIT OPERATIONS-2										Credits	5		
Course Code	0	9	B	T	4	D	C	U	O	2	L-T-P	3	1	1

Pre-requisites:
Knowledge of Process Engineering Thermodynamics and Process Principles and Calculations.

PART A; THEORY + TUTORIAL

UNIT 1 **[8L+2T]**

CONDUCTIVE HEAT TRANSFER

Modes of heat transfer, Conduction - Steady state heat conduction through unilayer and multilayer walls, Insulation-Types, critical thickness of insulation.

UNIT 2 **[9L+ 3T]**

CONVECTIVE HEAT TRANSFER

Overall & Individual heat transfer co-efficients, LMTD Forced & natural convection Condensation - Film wise & drop wise condensation, Heat Transfer equipments - Double pipe heat exchanger, Shell and Tube heat exchanger.

UNIT 3 **[7L+2T]**

BASICS OF MASS TRANSFER

Mass transfer Operations, Diffusion – Types, Fick's Law of Diffusion, Measurementof diffusivity, Mass transfer coefficients, Dimensionless Numbers.

UNIT 4 **[9L+2T]**

MASS TRANSFER OPERATION – I

Distillation - Methods of distillation, Distillation of binary mixtures – Raoults law, McCabe Thiele method, Extraction – leaching operation, aqueous two phase separations

UNIT 5 **[8L+2T]**

MASS TRANSFER OPERATION - II

Adsorption, Ion exchange, Evaporation, Drying, crystallization.

Course Outcomes:

1. Apply mathematical knowledge to formulate and analyze problems related to steady state heat conduction and insulation.
2. Understand the working principle and construction of Heat exchangers and Solve related problems.
3. Analyze diffusional processes and estimate flux and mass transfer coefficients in a diffusion process.
4. Describe different methods of distillation and predict the number of theoretical stages in a fractional distillation column.
5. Explain working principle of various separation processes and equipment required.
6. Apply the concepts of mechanical operations, momentum transfer, heat transfer and mass transfer operations in lab experiments.

TEXT BOOK

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

REFERENCE BOOK

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

PART B :UNIT OPERATIONS LABORATORY (2HRS/WEEK)

The experiments should cover any 12 of the following topics.

A) Momentum Transfer

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

B) Mechanical Operations

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

C) Heat Transfer

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

D) Mass Transfer

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

Course Title	ENGINEERING MATHS-IV (BIOSTATISTICS AND BIOMODELING)										Credits	4		
Course Code	0	9	B	T	4	D	C	M	A	T	L-T-P	3	1	0

Pre-requisites:
Knowledge of Engineering Mathematics I, II and III

UNIT 1 **[7L+3T]**
STATISTICS
Scope of Biostatistics, Measures of central tendency (mean, median, mode), Measures of dispersion (quartile deviation, mean deviation and standard deviation, coefficient of variation). Correlation and regression , curve fitting (linear, non-linear and exponential curves)

UNIT 2 **[8L+3T]**
PROBABILITY
Axioms, addition rule, multiplication rule, conditional probability, Bayes' theorem, Discrete distributions - Binomial, Poisson. Continuous distributions– exponential, gamma, normal and Weibulldistributions.

UNIT 3 **[7L+2T]**
MARKOV CHAIN AND GENETIC APPLICATION
Markov Chain: Probability vectors, stochastic matrices, fixed points, regular stochastic matrices. Markov chains, higher transition probabilities, stationary distribution of regular Markov chains and absorbing states

Genetic Applications of Probability, Hardy - Weinberg law, Wahlund's Principle, Forensic probability determination, Likelihood of paternity, Estimation of probabilities for multi-locus/multi-allele finger print systems

UNIT 4 **[9L+3T]**
STATISTICAL INFERENCE
Introduction, procedure for testing of hypothesis, level of significance and confidence interval estimation.
Test of significance for large samples: mean ,difference between two means, difference of two standard deviations, single proportion ,difference between two proportions, Test of significance for small samples: students t-distribution, F- distribution, Chi -Square distribution, goodness of fit test. Analysis of variance (one-way and two-way classifications).

UNIT 5 **[8L+2T]**
BIOMODELING
Microbial Growth in a Chemostat, Growth Equations of Microbial populations,Models of Commensalisms, Mutualism, Predation and Mutation. Volterra's Model for n -interacting Species. Basic Models for Inheritance, Selection and Mutation Models, Genetic Inbreeding Models.

Course Outcomes:

1. Estimate the relation between two variables and perform regression analysis
2. Apply the basic principles of probability and probability distributions to the problems of Bio-technology
3. Calculate transition probabilities using Markov chain
4. Test hypothesis for a given data and conduct ANOVA
5. Use model growth equations of microorganisms under different setups.
6. Illustrate the use of bio-models for genetic applications

TEXT BOOKS

1. **Biostatistics** by Wayne W.Daniel ,seventh edition
2. **Fundamentals of Biostatistics** by Veer Bala Rastogi , Ane books India
3. **Mathematical Models in Biology and Medicine** by J.N.Kapur, East-west press Private Ltd. New Delhi.

REFERENCE BOOKS

1. **Fundamentals of statistics** by Khan and Khanum
2. **An Introduction to Biostatistics** by P.S.S.Sundar Rao and J.Richard, Prentice Hall of India
3. **Mathematical models in Biology** by Elizabeth.S.Allman, Cambridge university press

QUESTION PAPER PATTERN

1. Each unit consists of one full question .
2. Each full question consists of three or four subdivisions.
3. Five full questions are to be answered.
4. Internal choice in Unit -2 and Unit -4.

Course Title	MOLECULAR BIOLOGY										Credits	4		
Course Code	0	9	B	T	4	D	C	M	L	B	L-T-P	4	0	0

Pre-requisites:
Knowledge of cell biology and genetics, basics of biomolecules

UNIT 1 **[9L+2T]**

INTRODUCTION: Information flow in biological systems, Structures and forms of nucleic acids - DNA and RNA, structural organization of genes and genomes

REPLICATION

Replication of DNA, Structure and function of DNA polymerases, proteins involved in replication, Models of replications in prokaryotes and eukaryotes.

UNIT 2 **[8L+2T]**

TRANSCRIPTION

Bacterial RNA polymerase - its structure and function. Sigma factors and sigma cycle
Eukaryotic RNA polymerases, Post transcriptional modifications Inhibitors of transcription

UNIT 3 **[8L+2T]**

TRANSLATION: genetic code and codon usage, Initiation, Elongation and termination of protein synthesis. Differences between prokaryotic and eukaryotic, Post translation modification, Inhibitors of translation.

UNIT 4 **[8T+2T]**

REGULATION OF TRANSCRIPTION AND TRANSLATION- Operon model, gal, lac, trp; Positive versus negative regulation of gene transcription, Regulation of eukaryotic gene expression, Role of Homeobox in the development of insects. Regulation of translation

UNIT 5 **[9L+2T]**

GENETIC RECOMBINATION AND REPAIR: Genetic recombination, Retroposons and Transposons and Insertion sequences. Recombination and Transposition in evolution. Recombination in viruses. Site specific recombination, Mutation and DNA damage and repair

Course Outcomes:

1. Explain with figures the features of NA structures and machinery of DNA replication
2. Comment on various components and detailed process of transcription and translation
3. Comprehend on models of gene expression and regulation
4. Describe different types of DNA damage and repair systems and recombination process

TEXT BOOKS

1. **GenesVII/VIII** by Lewin
2. **Molecular Biology of the Cell** by Bruce Alberts et al.garland Science Pub.(4^{th} ed.).
3. **Biochemistry** by Voet and Voet Wiley New York.

REFERENCE BOOKS

1. **Molecular Biology** by Freifelder
2. **Molecular Biology** by Watson
3. **Cell and Molecular Biology** by Gerald Karp. John Wiley & sons
4. **Cell and Molecular Biology** by Lodish. Freeman publ.

Course Title	BASICS OF COMPUTER APPLICATIONS										Credits	4		
Course Code	0	9	B	T	4	D	C	B	C	A	L-T-P	3	1	0

Pre-requisites:
Knowledge of Basics of computer concepts, Molecular Biology.

UNIT 1 **[9L+3T]**

OPERATING SYSTEM CONCEPTS

Introduction to O.S., types of O.S., O.S services, system calls, system components, system structures, virtual machines. Process and Memory Management - Process concept, process scheduling, co-operating processes, inter process communication, concept of threads and multithreading. Memory management – memory allocation schemes contiguous allocation, swapping, compaction, paging, demand paging, segmentation.

UNIX/Linux: Introduction to Linux, basic commands, working with the files, file attributes, pipes, wildcards, working with processes working with basic editors (vi, emacs). Shell programming; basic decision making statements if…then, else…if – test, while…do…done – until…do…done – for…in…do…done – case…in…esac – select…in…do, basic regular expressions, string search applications using regular expressions.

UNIT 2 **[8L+2T]**

BASICS OF DATABASES

Introduction to flat files, DBMS (Data Base Management System), RDBMS (Relational DBMS), introduction to SQL, basic commands, using SQL in MS Access, creating and modifying tables, joining tables, simple queries using SQL, inner join, outer joins, data sorting filters. Biological databases – Introduction, primary and secondary databases, types - Nucleic acid, Protein, protein profile, protein-protein interactions databases, database of metabolic pathways and structural databases, genome wide databases, drug databases and databases of naturally occurring compounds

UNIT 3 **[7L+2T]**

INTERNET AND BIOLOGY

Introduction to network, types of network, network architecture, internet, internet addresses. Internet protocol suit - transport layer protocols, upper layer protocols, internet access and applications, overview of HTML and HTTP, web services, WWW proxies. Biological search engines for DNA/RNA/Protein sequence and motif/domain search, MEDMINER, SCIRUS, PubMed and IBM motif search.

UNIT 4 **[9L+2T]**

INTRODUCTION TO PERL

An overview of Perl: Getting started, Statement blocks, ASCII, Unicode, Escape sequences, White spaces, Numerical data types, strings in Perl. Operators, Variables: special variables, regex (regular expression) variables, Input/Output variables, Filehandle variables, error and system variables. Perl statements, Introduction to statements, Types - Input/Output statements, conditional statements, looping, and jumping statements.

Lists, Arrays and Hashes: Introduction to simple lists, complex lists, and accessing list values. Arrays – initilising array, adding elements to an array, accessing single and multiple elements from an array. Array manipulating functions (pop, push, shift, unshift, splice, sort). Introduction to Hashes, creating a hash, working with hashes, adding, changing and accessing hash values.

Regular expressions: Introduction to regular expressions, patterns, metacharacters, anchors, modifiers, grouping and alteration. Matching, substitution, translation and binding operators, character classes. Posix and Unicode character classes, back reference variables. Applications of regular expressions.

UNIT 5 **[8L+2T]**

BIOPERL

Brief introduction to subroutines, packages and modules, difference between subroutines and modules. Introduction to BioPerl, BioPerl modules and packages – Bio::Perl, SeqIO, Bio:: DB::GenBank, Bio::Index, AlignIO, bp_ondex, bp_fetch etc., BioPerl objects, brief introduction to Seq, SeqI, PrimarySeq, RefSeq, RelSegment, LiveSeq, LargeSeq objects. Using BioPerl: Accessing sequence data from local and remote database, Indexing and accessing local databases, Transforming sequence files, Performing sequence alignments – running remote blast, stand alone blast and performing alignment of two sequences, performing multiple sequence alignment. Transforming alignment files.

Course Outcomes:

1. Comprehend the different types of operating system concepts and work with different operating system environments
2. Apply the concept of SQL to create and access the databases and can develop a database
3. Apply the concept of networks, internet, web services and HTML to construct a website.
4. Describe the different data types of PERL and its functions and write the PERL scripts for various applications
5. Comprehend the BIOPERL PACKAGE and write the BIOPERL scripts for biological applications

TEXT BOOKS

1. **Operating system concept** by Silberschatz, Peterhalvin and Greg Gauge, VI edition, John Wiley, 2003.
2. **Linux: The complete reference** by Richard Peterson, McGraw Hill, 1998.
3. **Perl cook book** by O'Reilly & Associates, USA, 1998.

REFERENCE BOOKS

1. **Operating system – A concept based approach** by D Dhamdene, Tata McGraw Hill, 2002.
2. **Introducing UNIX and Linux**, Ane Books, India.
3. **Learning Perl (III edition)** by Tom Christiansen, Jon Orwant, Larry Wall, 2001.
4. **Perl in Nutshell**, O'Reilly, 2001.
5. **SAMS teach SQL yourself in 10 minutes** by Ben Forta, 3rd Edition
6. **SQL Queries for more mortals: A hands on guide to data manipulation in SQL** by Michael J. Hernandez and John L. Viescas (2000).
7. **Internet: The complete reference** by Margaret Levine young, Tata McGraw Hill, 1999.
8. **A First course in database systems** by Jeffrey D. Ullman and Jennifer D. Widon. (2nd Ed.)
9. **Beginning Perl** by Simon Cozens, Peter Wainwrigth. Tom Christiansen and Nothan Torkinton, Wrox press, 1st edition, 2000.

Course Title	PROCESS PRINCIPLES AND CALCULATIONS										Credits	4		
Course Code	0	9	B	T	4	D	C	P	P	C	L-T-P	3	1	0

Pre-requisites:
Knowledge of Engineering chemistry & mathematics, unit operations

UNIT 1 **[9L+2T]**
INTRODUCTION TO BIOPROCESS CALCULATIONS
Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases. Concept of normality, Molarity, Molality, ppm. pH, pKa calculations.

UNIT 2 **[9L+2T]**
IDEAL GAS LAW CALCULATIONS
Ideal gas law calculations, Vapour-Pressure concept, Saturation, Partial saturation, molal, absolute humidity concepts. Humidity chart

UNIT 3 **[5L+2T]**
MATERIALS BALANCE WITHOUT REACTION
General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing, evaporation, Humidification & dehumidification. Elementary treatment of material balances involving bypass, Recycle

UNIT 4 **[9L+3T]**
STEADY STATE MATERIAL BALANCE WITH REACTION
Principles of Stoichiometry, Concept of limiting, excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, recycle & purging, Fuels:Proximate and Ultimate analysis of coal, Combustion Calculations

UNIT 5 **[9L+3T]**
ENERGY BALANCE
General steady state energy balance equation, Thermo physics. Thermo chemistry and laws. Heat capacity. Enthalpy, Std Heat of formation, Std Heat of reaction, Std Heat of combustion and Calorific values. Heat of solution. Heat of mixing, Heat of crystallization. ΔHc calculations, elevated temperatures, Stoichiometry of microbial growth & product formation, yield coefficient Concepts, Elemental material balance.

Course Outcomes:
1. Apply the basic concepts of process calculations in biochemical engineering applications.
2. Formulate and solve the material balances on steady state unit operations involving with & without reaction.
3. Formulate and solve the energy balances of chemical reactions.
4. Formulate and solve the stoichiometric equations for microbial growth & product formation.

TEXT BOOKS

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

REFERENCE BOOKS

1. **Chemical Process Principles Part – I** by Hougen O. A., Waston K. M. and Ragatz R. A., Wiley, New York
2. **Stoichiometry (SI Units**) by Bhatt B. L. and Vora S. M. . Tata McGraw Hill (3^{rd} Ed.), 1996.
3. **Material and Energy Balances**. CBS publishers and distributors. New Delhi. 1995.

Course Title	BIOANALYTICAL TECHNIQUES										Credits	4		
Course Code	1	0	B	T	5	D	C	B	A	T	L-T-P	4	0	0

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

UNIT 1 **[12 hrs]**

CHROMATOGRAPHIC TECHNIQUES

Introduction, general principle, classification of chromatography, partition coefficient, retention time, retention volume, elution time and volume, column efficiency and resolution, internal and external standards, sample preparation. Paper chromatography (ascending, descending and two dimensional chromatography): principle, apparatus, paper development, solvent system, detection and application. Thin layer chromatography: principle, plate development, application of sample, detection and applications. Adsorption chromatography: principle, simplified theory of adsorption, operational procedure, types and application. Gas liquid chromatography: apparatus, selection of column, preparation and application of sample, detectors and applications. Ion exchange chromatography: principle, types, matrices and applications. Gel filtration chromatography: principle, matrices and applications. Affinity chromatography: Principle, matrices, types and applications. High performance liquid chromatography: principle, column, matrices, column packing, pumps, application of the sample, detection and applications.

UNIT 2 **[08 hrs]**

ELECTROPHORESIS

Introduction, electrophoresis principle, migration of ions in an electric field, factors affecting the electrophoretic mobility, types of electrophoresis. Moving boundary and zone electrophoresis (paper and cellulose acetate electrophoresis).Gel electrophoresis: types of gel-starch gel, agar, polyacrylamide, agarose-acrylamide, solubilizers, electrophoretic procedure, detection recovery, estimation and applications. Specialized electrophoretic techniques: discontinuous (disc) gel electrophoresis (SDS-PAGE), high voltage electrophoresis, immune electrophoresis, isoelectric focusing and pulsed field gel electrophoresis.

UNIT 3 **[11 hrs]**

BIOPHYSICAL TECHNIQUES

Rayleigh scattering, ultra centrifugation, viscometry. Electron microscopy, STM, AFM, luminescence (fluorescence & phosphorescence), Calorimetry, DSC, Mass spectrometry, LC-MS, MALDI-TOF, Voltage Clamp and Patch Clamp (measurements of membrane potentials)
(Only principle, Instrumentation and applications and no derivation required).

UNIT 4 **[11 hrs]**

SPECTROSCOPIC TECHNIQUES

X-ray Spectroscopy: structure determination via single crystal diffraction, fibre diffraction; Neutron diffraction. XAFS. NMR spectroscopy (structure determination). Optical Activity, CD, UV, IR, Laser, Raman, ESR/EPR. (Only principle, Instrumentation and applications and no derivation required).

UNIT 5 **[10 hrs]**

IMMUNOANALYTICAL METHODS

Immunoassays- Preparation and sampling of antigens and antibodies, Design of an immunoassay, criteria for assay and protocols, RIA, ELISA, Radio receptor assay (RRA), Immunofluorescent analysis by flow cytometry-principle, instrumentation, staining and analysis. Immunofluroscence studies using confocal laser scanning microscopy-introduction, optical principle, laser sources and flurophores, standard protocols for labeling.

Course Outcomes:

1. Understand the principle and applications of various separation techniques in biomolecular separations
2. Select and describe the principle and methods of biomolecular purifications
3. Understand the principle and concepts of various biophysical techniques in biomolecular identification
4. Explain the principle and methods of contemporary techniques in biomolecular analysis.

TEXT BOOKS

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

REFERENCE BOOKS

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

Course Title	BIOINFORMATICS										Credits	4		
Course Code	1	0	B	T	5	D	C	B	I	N	L-T-P	3	0	1

Pre-requisites:
Knowledge of Basics of computer concepts and applications, Molecular Biology, Basics of Biomolecules, Biochemistry.

PART A: THEORY

UNIT 1 **[06 hrs]**

DATABASES & TOOLS

Introduction to Bioinformatics: Aim, Scope and role of Bioinformatics in Biotechnology industry; Branches; History; current and future trends.

Bioinformatics resources: NCBI, EBI, ExPASy, RCSB; Significance of databases towards informatics projects. Databases: History, features, Classification; Nucleotide and protein sequence Databases: GenBank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, and TrEMBL.

Format of databases: Sequence and Structural formats: Gene bank flat file, Protein Data Bank (PDB) flat file; FASTA Format, PIR Format; Structure file formats: PDBSUM, PDBLite, MMDB, SCOP, Pfam Specialized databases: NCBI, Pubmed, OMIM, Medical databases, KEGG, EST databases.

UNIT 2 **[12 hrs]**

SEQUENCE ALIGNMENT AND DATABASE SEARCHES

Sequence Alignment: Introduction, The evolutionary basis of sequence alignment, the Modular Nature of proteins, Optional Alignment Methods, Substitution scores, substitution matrices, PAM, BLOSUM, Gap penalties, Statistical significance of Alignments, Pair wise alignment – Dotplot, Global, Local; DNA and Protein Scoring/Substitution matrices – Basic matrices, PAM, BLOSUM; Gaps and Gap scores; Dynamic Programming - Needleman & Wunch, Smith & Waterman; statistical significance of alignments. Multiple sequence alignment; Algorithms and methods - Progressive pair wise methods - Clustalw/clustalx, Iterative methods, profile based methods- PSSM;Sequence similarity search: Introduction; FASTA, BLAST, Low-Complexity Regions, Repetitive Elements. Conceptual numericals.

UNIT 3 **[09 hrs]**

PHYLOGENETIC ANALYSIS AND PREDICTIVE METHODS

Introduction to Phylogenetic analysis: Tree terminologies, Forms of tree representation- Rooted and Unrooted trees; Steps in Phylogenetic data analysis; Tree building Methods: Distance based vs. character based – UPGMA, NJ, FM and Maximum likelihood, Maximum parsimony; Assessing tree reliability: Bootstrapping. Phylogenetic softwares: CLUSTALW, PAUP, PHYLIP etc, Conceptual numerical. Predictive Methods: Genome sequence acquisition and analysis: Defining genomes- (Definition, how are whole genome sequenced, E-value, prediction of protein functions) and the human genome draft sequences (overview, summary statements); Web based tools (GENSCAN, GRAIL, GENEFINDER).

UNIT 4 **[06 hrs]**

PLASMID MAPPING, PRIMER DESIGN, PROTEIN STRUCTURE VIZUALIZATION

Restriction mapping: Utilities, various steps involved, Web based tools; Primer design: need for tools, Primer design programs and software (PRIME3); Structure Visualization and Graphical representation

of molecular structures, Usages of visualization software available in public domain like VMD, Rasmol, Pymol, SpdbViewer, Chime, Cn3D. Conceptual numericals.

UNIT 5 **[06 hrs]**

MOLECULAR MODELING, DRUG DESIGN AND DISCOVERY

Generation of Rational Approaches in Drug Design, molecular docking, quantitative structure-activity relationship (QSAR), Receptor Mapping, Estimating Biological Activities, Molecular Interactions: Docking, Calculation of Molecular Properties, Energy Calculations (no derivation),
Target identification, Target validation, Modeling, Virtual screening, lead identification, Lead Validation, and Molecular Interactions.

Course Outcomes:

1. Describe and classify different types of bioinformatics resources, biological databases and their file formats.
2. Perform sequence alignment, analyze and interpret the data.
3. Perform phylogenetic analysis and interpret the data.
4. Perform restriction mapping, design a primer and visualize the protein structures using software tools.
5. Understand the concepts of molecular modelling and drug design process and will apply Insilco using bioinformatics tools.

TEXT BOOKS

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

REFERENCE BOOKS

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

PART B: BIOINFORMATICS LABORATORY

1. Sequence retrieval from nucleic acid and protein databases
2. Sequence (FASTA and BLAST) searches – Analysis of parameters affecting alignment.
3. Pair wise and multiple alignments of sequences – Analysis of parameters affecting alignment.
4. Evolutionary studies / Phylogenetic analysis – Identification of orthologs and paralogs.
5. Restriction mapping - Analysis of maps for suitable molecular biology experiments.
6. Primer Design- Factors affecting primer design.
7. Identification of functional sites in Genes / Genomes.

8. Pattern elucidation in Proteins using PROSITE.
9. PDB Structure retrieval, Visualization and analysis of Protein Ligand interactions
10. Secondary structure prediction of proteins and structure prediction by threading methods.
11. 3D Structure prediction by Homology Modeling and Validation of modeled 3D structures – Structural analysis.
12. Superposition of structures – Calculation of RMSD and analysis.

Course Title	ENZYME KINETICS & REACTION ENGINEERING										Credits	4		
Course Code	1	0	B	T	5	D	C	E	K	R	L-T-P	4	0	0

Pre-requisites:
Knowledge of Microbiology and Process Principles and Calculations.

UNIT 1 **[11 hrs]**

REACTION KINETICS AND IDEAL BIOREACTORS

Law of mass action and rate equation, definitions and examples of elementary and non-elementary reactions, theories of reaction rate and temperature dependency, analysis of experimental reactor data: evaluation of rate equation, half life method, integral and differential analysis for constant volume system. Design equations for homogeneous system: batch, stirred tank and tubular flow reactor, size comparison of reactor systems, combination reactor systems. Optimization of output and yield problems, Qualitative design for consecutive, parallel and mixed reactions and recycle. Factors affecting choice of reactors: optimum yield, conversion, selectivity and reactivity. Conceptual numericals.

UNIT 2 **[10 hrs]**

NON-IDEAL BIOREACTORS

Non-ideal reactors, residence time distribution studies, pulse and step input response of reactors, RTD's for CSTR and PFR, calculations of conversions for First order reactions, tanks in series and dispersion models. Reactor Modelling with RTD, Zero Parameter Models Analysis of Nonideal Reactors: Basic Method, One Parameter Models, Two Parameter Models, Testing a Model and determining its Parameters, RTD vs. Models. Conceptual numericals

UNIT 3 **[10 hrs]**

DESIGN AND ANALYSIS OF BIOREACTORS

Stability and analysis of bioreactors, biomass production and effect of dilution rate. Design and operation of various bioreactors, eg. CSTF, fedbatch systems, airlift bioreactors, fluidized bed reactors, scale up of bioreactors, criteria for selection of bioreactors.

UNIT 4 **[11 hrs]**

ENZYME KINETICS

Enzyme active site, types of enzyme specificities, enzyme kinetics, initial velocity studies, formation of ES complex, derivation of Michaelis-Menton equation, definition of Km and Vmax, Lineweaver-Burk and Eadie-Hofstee plots. Units of enzyme activity, Enzyme inhibition: competitive, uncompetitive and non-competitive; Regulations – allosteric and feedback regulation. Conceptual numericals.

UNIT 5 **[10 hrs]**

KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION

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

Course Outcomes:

1. A. Use concepts to measure reaction rates of chemical reactions using different methods,
   B. Derive design equations for different reactors at steady state as well as analyze problems.
   C. Explain factors influencing the choice of ideal reactors.
2. Estimate the Residence time distributions for various non-ideal reactors and also compare various Models.
3. Describe the operation of various bioreactors and the factors influencing the selection and scale-up process.
4. Comprehend enzyme properties, kinetics and mechanisms and solve problems related to Enzyme kinetics.
5. Understand the kinetics and models of microbial growth as well as identify, interpret and solve stoichiometry problems related to biochemical engineering applications.

TEXT BOOKS

1. **Chemical Reaction Engineering** by Levenspiel O., John Wiley, Third Edition, 2006.
2. **Elements of Chemical Reaction Engineering** by Fogler, H.S., Prentice Hall, 1986.
3. **Bioprocess Engineering** by Shuler and Kargi, Prentice Hall, Second Edition, 2005.
4. **Enzyme Kinetics and Mechanism** by Paul F Cook & W W Cleland, Garland Science, 2007

REFERENCE BOOKS

1. **Bioprocess Engineering** by Aiba, Humprey & Millis, Academic Press, Second Edition, 1973
2. **Biochemical Engineering** by James Lee, Prentice Hall, 1992.
3. **Biochemical Engineering Fundamentals** by Bailey and Ollis, McGraw Hill, Second Edition, 1986.
4. **Bioprocess Engineering Principles** by Pauline M. Doran, Academic Press, 1995.
5. **Principles of Biochemistry by** Leninger A.L., Second Edition, 1993.
6. **Enzyme Kinetics** by Plowman, McGraw Hill, 1972.Chemical Engineering Kinetics by Smith J.M., McGraw Hill, Third Edition, New Delhi, 1981.

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

Pre-requisites:
Strong knowledge of molecular biology

PART A: THEORY

UNIT 1 **[10L+4T]**

GENE CLONING CONCEPTS

Background information, scope and objectives. Gene cloning strategy - steps in creating a recombinant DNA. Tools: Vectors - types of cloning vectors – for bacteria - plasmids, bacteriophages, cosmids, phagemids; for yeasts – yEPs, yIPs, yRPs, YACs; retro viral vectors ,adenoviral vectors; Ti plasmids; Expression vectors – purpose and construction. Enzymes: Nucleases – DNAses- exo- and endonucleases , RNAses, polymerases – DNA polymerases, reverse transcriptase, RNA polymerase, Ligases, Restriction enzymes, Modifying enzymes – alkaline phosphatase, polynucleotide kinase, terminal transferase.
Linkers and adaptors.

UNIT 2 **[7L+2T]**

NUCLEIC ACIDS: ISOLATION, AMPLIFICATION AND SEQUENCING

Isolation and purification of nucleic acids – Plasmid, Phage, prokaryotic and eukaryotic DNA, RNA and quantification. Southern blotting, Northern blotting, Western blotting and Southwestern blotting.Polymerase chain reaction (PCR) – principle, applications and variants of PCR technique. Sequencing of DNA – Sanger's method. Chemical synthesis of DNA, M13 and PCR mediated mutagenesis.

UNIT 3 **[7L+2T]**

GENE TRANSFER TECHNIQUES AND DNA LIBRARIES

Gene transfer techniques – physical – electroporation, microprojectile, microinjection; chemical – calcium chloride, calcium phosphate mediated delivery, lipofection, Biological –Viral vector mediated methods.Construction of genomic and cDNA libraries.Screening techniques – direct selection, detection by nucleic acid hybridization – colony and plaque hybridization, immunological screening methods.

UNIT 4 **[7L+3T]**

EXPRESSIONS OF CLONED GENES

Gene expression: Components for gene expression and control of expression - promoters (prokaryotic & eukaryotic), strong and weak promoters, factors influencing translational efficiency: RB sites, SD sequences, codon bias. Gene expression –in Pk- host cell, translation, folding, solubility, post translational modification compatibilities, EK- fungi (yeast and other fungi), animals and animal cells.

UNIT 5 **[8L+2T]**

APPLICATIONS

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

Course Outcomes:

1. Understand the concepts and apply various tools and techniques in amplification, manipulation and detection of a gene.
2. Differentiate various gene transfer methods and describe design and construct DNA library
3. Comprehend factors and components responsible for expressions of a gene
4. Apply the concepts of gene manipulation in development of GMOs for health and environment
5. Isolate , analyze nucleic acids and use tools for gene manipulation

TEXT BOOKS

1. **Introduction to Genetic Engineering** by Nicholl. Cambridge Low Price Edition.
2. **Principles of gene manipulation - An introduction to genetic engineering** by Old R.W., Primrose S.B., Blackwell Scientific Publications, 1993.
3. **From Genetics to Gene Therapy – the molecular pathology of human disease** by David S Latchman, BIOS scientific publishers, 1994.
4. **Genes VIII** by Benjamin Lewis. Oxford University & Cell Press.
5. **DNA Science** by David A Micklos, Greg A Freyer and David A Crotty, I K International, 2003.

REFERENCE BOOKS

1. **Gene Cloning & DNA Analysis: An Introduction** by Brown T A, 2006, Fifth edition, Blackwell Science.
2. **Molecular Biotechnology: Principles and Applications of Recombinant DNA** by Glick, B R, Pasternak .J J, 2003, Third edition, DC ASM Press.
3. **Principles of gene manipulation** by Primrose.

PART B: GENETIC ENGINEERING AND IMMUNOTECHNOLOGY LABORATORY

1. Preparation of DNA for PCR applications – Isolation, purity & quantification (Plant/Animal/Bacteria).
2. Introduction to PCR- working of PCR equipment, programming, preparation of reagents and buffers.
3. Restriction digestion, agarose gel electrophoresis and size determination.
4. Isolation of plasmid DNA from *E.coli and trasformtion.*
5. Gene /DNA amplification by random /specific primers.
6. Southern hybridization
7. Gene cloning
8. Bacterial agglutination technique-Widal/VDRL test
9. ODD & RID
10. Quantitative ELISA.
11. Western blotting.
12. Ammonium sulphate fractionation and column separation.
13. Phage titration.
14. Dot ELISA.

Course Title	IMMUNOTECHNOLOGY										Credits	4		
Course Code	1	0	B	T	5	D	C	I	M	M	L-T-P	4	0	0

Pre-requisites:
Knowledge of Cell biology and Genetics, Molecular Biology, Human physiology, Basics of Biomolecules and Biochemistry

UNIT 1 **[08 hrs]**

INTRODUCTION TO IMMUNE SYSTEM

Historical development, Innate (non-specific) and Adaptive (specific) immunity, Passive and active immunity, Humoral and Cell mediated, Cells & Organs of Immune System, Overview of immune response

UNIT 2 **[14 hrs]**

B-CELL AND THEIR FUNCTION- STAGES OF B-CELL DEVELOPMENT, TYPES, RESPONSE TO ANTIGENS (ACTVATION, SIGNAL TRASDUCTION AND DIFFERENTIATION)

Immuno globulins – types: IgG IgA, IgE, IgD and IgM; structure and function, Organization and Expression of Immunoglobulin Genes, Polyclonal antibodies and Production of monoclonal antibodies by hybridoma technology. *B*-Cell generation, activation, differentiation and antigen-antibody interactions. T-CELL RESPONSES - Antigen Processing and Presentation, Major Histocompatibility Complex. T-Cell ontology, receptor and other surface markers, T-B interaction. T helper cell activation and differentiation, Cytotoxic T-cell activation and differentiation and function. N k cell, Macrophages, Dendritic cells and their function

UNIT 3 **[14 hrs]**

IMMUNE EFFECTOR MECHANISMS AND IMMUNOLOGICAL DISORDERS

The Complement System – Classical, Alternate and MBL –pathways. And Hypersensitivity Reactions-Type I, II, II and IV

IMMUNE SYSTEM IN HEALTH AND DISEASE -- Immune response to infections -bacterial, viral, fungal and parasitic diseases, Immunodeficiencies- Primary and Secondary (AIDS), Autoimmunity - types of autoimmune disorders, mechanism,

Transplantation Immunology – types of grafts (auto, allo, xeno and isografts), Mechanism of rejection, mmunosuppression, Tissue typing, Cancer and Immune system

UNIT 4 **[08 hrs]**

VACCINES AND THERAPEUTIC ANTIBODIES

Types- Whole organism, Subunit (Protein, CHO and Synthetic peptide), and DNA vaccines, recombinant Viral vaccines, Application of PCR for production of recombinant antibodies. Antibody heteroconjugates, Immunotoxins, Humanized and CDR grafted antibodies.

UNIT 5 **[08 hrs]**

IMMUNOTECHNIQUES

Antigen – Antibody Reactions, Affinity, Avidity, Cross-Reactivity, Immunoprecipitations- Precipitation Reactions & Agglutination Reactions, Radioimmunoassay, Enzyme-linked Immunosorbent Assay, Western Blot, Immunoelectrophoresis. Immunofluorescence, Flow Cytometry, Immunoelectron Microscopy, Affnity chromatography

Course Outcomes:

1. Identify various branches of immune system and summarize overall of immune response.
2. A. Draw structure of antibody molecules and describe their role and method of production.
   B. Draw structure of immune cells and organs and describe their function & mechanism of action
   C. Distinguish MHC class I and class II by their structure and role and illustrate antigen processing pathways.
3. Explain the role of immune system in health, disease and transplant rejection
4. Classify vaccines and recombinant antibodies and list their applications
5. Conduct experiments and interpret results involving detection and quantification of antigens and antibodies.

TEXT BOOKS

1. **Immunology** by Richards A Goldsby, Thomas J. Kindt, Barbara A. Osborne, Janis Kuby. W.H. Freeman & Co, Fifth edition, 2003.
2. **Essential Immunology** by Roitt I. Blackwell Scientific Publications, Oxford, 1991.

REFERENCE BOOKS

1. **Practical immunology** by G.P.Talwar (Vol 1 & 2)
2. **Immunology – an Introduction** by Tizard, Thomson 2004.
3. **Fundamental Immunology** By William E Paul, sixth Edition

Course Title	BIOSENSORS AND BIOINSTRUMENTATION										Credits	4		
Course Code	1	0	B	T	5	D	E	B	B	I	L-T-P	4	0	0

Pre-requisites:
Knowledge of Human Physiology, Engineering Physics, Basics of Electrical and Electronics

UNIT 1 **[14 hrs]**

FUNDAMENTALS OF MEDICAL INSTRUMENTATION

Anatomy and physiology, physical systems of the body, sources of biomedical signals, Design of medical instruments, components of the biomedical instrumentation system, General constraints in design of medical instrumentation systems, Regulation of medical devices; The terminology of medical instrumentation, a review of medical and physiological signals, Principles of EEG, ECG and EMG, PC based Instrumentation; Bioelectric Signals and Electrodes: Origin of bioelectric signals, Recording electrodes, - Electrode-tissue interface, metal electrolyte interface, electrolyte - skin interface, Polarization, Skin contact impedance, Silver – silver chloride electrodes, Electrodes for ECG, EEG, EMG, Electrical conductivity of electrode jellies and creams, Microelectrode; Physiological Transducers: Introduction, classification of transducers, performance characteristics of transducers, Classification, displacement, position, motion , pressure, temperature, photoelectric, optical fibre sensor transducers ; Conceptual numerical.

UNIT 2 **[10 hrs]**

CARDIOVASCULAR SYSTEM

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

UNIT 3 **[08 hrs]**

RESPIRATORY SYSTEM

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

UNIT 4 **[06 hrs]**

AUTOMATION AND ROBOTICS

Introduction to Automation, types, LERT classification system, Robotics: Definition, Purpose, components, Types & softwares used in robotics, Barcode technology, objectives, decoding, symbologies, used barcode reader (pen-type, laser type, CCD camera and camera based readers) Conceptual numerical.

UNIT 5 **[14 hrs]**

BIOSENSORS

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

4+65 invasive biosensors in clinical analysis; Application of biosensors to environmental samples- Pesticide detection and other various toxic compounds, use of biosensors for pollution control; Biosensors in aquatic and soil samples; Benefits of biosensors to bioprocess and its challenges; Electrochemical sensors, chemical fibro sensors, ion selective FETs, Micro Electromechanical sensors(MEMS) and the commercial development of biosensors, Blood glucose sensors, Biochip-Introduction and structure of DNA Chips, design and operating principles, related instruments; BIA core- an optical biosensor.

Course Outcomes:

1. Comprehend the principle, components, functions and applications of different biomedical devices
2. Describe the different types of biomedical devices for various measurements related to cardiovascular system and respiratory system
3. Classify and understand the concepts of Automation, Robotics and BAR code technology
4. Comprehend the principle, functions and applications of different biosensors and their components for various applications and select the components to design a biosensor

TEXT BOOKS

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

REFERENCE BOOKS

1. **Hand Book of Biomedical Instrumentation** by R. S. Khandpur, Second Edition, Tata McGraw-Hill, 2008
2. **Advances in Laboratory Automation-Robotics** by J.R. Strimaitis and J.E.N. Little, Zymark Corporation, MA, 1991.

Course Title	COMPUTATIONAL BIOLOGY										Credits	4		
Course Code	1	0	B	T	5	D	E	C	T	B	L-T-P	4	0	0

Pre-requisites:
Knowledge of Statistics, Basics of Computer applications, Molecular Biology, Genetic Engineering and Genomics & Proteomics

UNIT 1 **[12 hrs]**

INTRODUCTION TO ALGORITHMS AND STATISTICAL APPROACH TO DNA AND PROTEIN SEQUENCE ANALYSIS

Introduction, Forward and backward algorithms, Viterbi and Estimation algorithms. Analysis of single DNA sequence: shotgun sequencing, DNA modeling, scanning long repeats, analysis of patterns and counting of overlaps. Analysis of Multiple DNA or Protein sequences: frequency comparisons of two sequences. Simple tests for significant similarity in an alignment. Alignment algorithms for two sequences: Gapped global comparisons and Dynamic programming algorithms, linear gap model for fitting one sequence into another and local alignment. Protein sequences and substitution matrices: BLOSUM, PAM and simple symmetric evolutionary matrix.

UNIT 2 **[11 hrs]**

GENOME ASSEMBLY AND EST CLUSTERING

Computational methods for genome assembly: assembling the Human genome, comparative methods for sequence assembly. Information theoretic approach to Genome reconstruction. Expressed Sequence Tags (ESTs): Clustering and applications, algorithms for large scale clustering and assembly of biological sequence data.

UNIT 3 **[08 hrs]**

COMPUTATIONAL METHODS FOR GENOMICS

Comparisons of long Genome sequences: algorithms and applications, chairing algorithms and applications in comparative Genomics, computational analysis of alternative splicing and Human genetic linkage analysis. Haplotype interface.

UNIT 4 **[11 hrs]**

STATISTICAL MODELS FOR EVOLUTION

Models of nucleotide substitution. Discrete time models: Jukes-Cantor model, Kimura models, Felsenstein models and simple symmetric amino acid model. Continuous time models: Continuous time Jukes-Cantor model, Continuous time Kimura model, Continuous time Felsenstein model and Continuous time amino acid model. Phylogenetic tree estimation: distances, inferred distances. Tree reconstruction methods: Neighbor joining, parsimony and Maximum Likelihood.

UNIT 5 **[10 hrs]**

COMPUTATIONAL METHODS FOR MICROARRAY AND GENE EXPRESSION ANALYSIS

Microarray data, annotations, storage and retrieval. Computational methods for Microarray design, border length minimization in DNA array design. Clustering algorithms for Gene Expression Analysis. Identifying gene regulatory networks from Gene expression data. Modeling and analysis of gene networks

using feedback control. Genome tiling for Microarray and Homology search. Rapid large scale oligonucleotide selection for Microarrays.

Course Outcomes:

1. Understand the role of algorithms and statistics in DNA and protein sequence analysis.
2. Comprehend various methods for genome assembly and identify the applications of ESTs clustering.
3. Describe computational methods and apply the concepts in comparative genomics.
4. Identify the characteristics of various statistical models for biological data.
5. Explain the methods and techniques for microarray and gene expression analysis.

TEXT BOOKS

1. **Algorithms in Bioinformatics** by Dan Gusfield., Second International Workshop, WABI 2002, Proceedings. Springer. 2002.
2. **Algorithms in Bioinformatics** by Inge Jonassen and Junhyong Kim.: 4th International Workshop, WABI 2004. Springer. 2004.

REFERENCE BOOKS

1. **Algorithms in Bioinformatics** by Dan Gusfield.: Second International Workshop, WABI 2002, Proceedings. Springer. 2002.
2. **Algorithms in Bioinformatics** by Inge Jonassen and Junhyong Kim.: 4th International Workshop, WABI 2004. Springer. 2004.
3. **Bioinformatics Algorithms: Techniques and Applications** by Ion Mandoiu and Alexander Zelikovsky, Wiley-Interscience. 2008.
4. **Introduction to Computational Biology: Maps, Sequences and Genomes** by Michael S. Waterman.CRC Press. 1995.
5. **Handbook of Computational Molecular Biology** by Srinivas A, CRC Press. 2006.
6. **Statistical methods in bioinformatics: an introduction** by Warren John Ewens and Gregory R. Grant, Springer. 2005.

Course Title	INDUSTRIAL BIOTECHNOLOGY										Credits	4		
Course Code	1	0	B	T	5	D	E	I	B	T	L-T-P	4	0	0

Pre-requisites:
Knowledge of Microbiology, Unit Operations, Biochemistry, Molecular Biology and Genetic Engineering

UNIT 1 **[09 hrs]**

INTRODUCTION

Introduction, Objectives and Scope; Characteristic and comparison of bioprocessing with chemical processing, Substrates for bioconversion processes and design of media, Isolation, preservation and improvement of industrial microorganisms, Metabolic basis for product formation, Cell culture techniques and aseptic transfers.

UNIT 2 **[09 hrs]**

PROCESS TECHNOLOGIES

Process technology for the production of cell biomass and some primary metabolites: ethanol, acetone-butanol, citric acid, enlipases, dextran and amino acids. Microbial production of industrial enzymes-glucose isomerase and cellulose, Production of secondary metabolites-penicillin and tetracycline, Production of vaccines.

UNIT 3 **[12 hrs]**

PRODUCTION OF ORGANIC ACIDS & ENZYMES

Organic Acids- Citric Acid, Fumaric Acid, Itaconic Acid, Kojic Acid, Bacterial Gluconic and –Ketogulatic Acid Fermentations with process Flow sheets, Enzymes as fermentation Products, Amylases, Proteolytic Enzymes, Pectinases, Invertase.

UNIT 4 **[12 hrs]**

PRODUCTION OF ORGANIC SOLVENTS

Anaerobic Fermentations, Acetone-Butanol Fermentation, Brewing, Industrial Alcohol, Lactic Acid Environmental Control of Metabolic Pathways, Glycerol from yeast, Glycerol from Bacillus subtilis,Genetic Control of Metabolic Pathways, Indirect or dual Fermentation, Direct Fermentation, Microbial Oxidative Transformations of Substrate, Vinegar, Gluconic Acid with process flow sheets.

UNIT 5 **[10 hrs]**

PRODUCTION OF FOOD PRODUCTS

Hydrocarbon Fermentations, Microbial Cells as Fermentation Products, Baker's yeast, cheese, Food and Feed Yeasts, Bacterial Insecticides, Legume Inoculant, Mushrooms, Algae, Vitamins and Growth Stimulants, Vitamin B12(Cobamide), Riboflavin, Vitamin A, Gibberellins, Steroid Transformation.

Note: Emphasis on Process Flow Diagram (PFD), blocked diagram to be given for process description wherever applicable.

Course Outcomes:

1. Identify the techniques to screen and selectively isolate industrially important microorganisms from various sources and also describe methods for fermentation media optimization.
2. Understand the techniques used for strain improvements, preservation and control mechanisms.
3. Distinguish the process technologies for large scale production of industrially important products from living organisms.

TEXT BOOKS

1. **Industrial Microbiology** by Prescott & Dunn, CBS Publishers, 1987.
2. **Industrial Microbiology** by Casida LE, Willey Eastern Ltd, 1989.

REFERENCE BOOKS

1. **Bioprosess Technology-fundamentals and applications** by Enfors SO and Hagstrom LRIT, Stockholm, 1992.
2. **Biotechnology, Economic & social Aspects** by Dasilva EJ, Ratledge C & Sasson. A Cambridge Univ. Press, Cambridge, 1992
3. **Environmental Biotechnology** by Foster CF and John ware DA. Ellis Horwood Limited. 1987.
4. Encyclopedia, Kirk and othmer, 2007
5. **Fuels from waste** by Larry Anderson and David A, TillmanAcademic Press, 1977.
6. **Comprehensive Biotechnology** by Young MY, Pergamon Press, 1985.
7. **Biotechnology: A Text Book of Industrial Microbiology** by Brock TD (1990), Smaeur Associates.
8. **Biotechnology, Economic & Social Aspects** by Dasilva EJ, Ratledge C & Sasson A, Cambridge Univ.Press, Cambridge, (1992)

Course Title	MANAGEMENT & ENTREPRENEURSHIP										Credits	4		
Course Code	1	0	B	T	5	D	E	M	G	T	L-T-P	4	0	0

Pre-requisites:
Knowledge of Personality Development and Communication, English and Mathematics

UNIT 1 **[11 hrs]**

a) MANAGEMENT

Introduction- meaning nature & characteristic of management, scope & functional areas of management. Management as a science, art or profession, management and Administration, Role of management, levels of management, Development of management thought –early management approaches – modern management and approaches.

b) PLANNING

Nature, Importance and purpose of planning process, objectives, types of plans (meaning only), decision – making, importance of planning, steps in planning and planning premises, Hierarchy of plans.

UNIT 2 **[11 hrs]**

a) ORGANIZING AND STAFFING

Nature and purpose of organization, principles of organization, Types of organization – Departmentation –committees – centralization v/s decentralization of authority and responsibility, span of control- MBO and MBE (meaning only), nature and importance of staffing, process of selection and recruitment (in brief).

b) DIRECTING & CONTROLLING

Meaning and nature of directing, leadership styles, motivation theories, communication- meaning and importance, co-ordination, meaning and importance, techniques of coordination, Meaning and steps in controlling, essentials of a sound control system, methods of establishing control (in brief).

UNIT 3 **[10 hrs]**

ENTREPRENEUR

Meaning of entrepreneur, characteristics and quality of entrepreneur, , evaluation of the concept function of an entrepreneur types of entrepreneur, evolution of entrepreneurship, development of entrepreneurship, stages in entrepreneurial process, role of entrepreneurs in economic development entrepreneurship in India, entrepreneurship - its barriers, women entrepreneur, problems of women entrepreneur, entrepreneurial development in India and EDP

UNIT 4 **[10 hrs]**

SMALL SCALE INDUSTRY AND INSTITUTIONAL SUPPORT

Definition, characteristics, need and rationale, objectives, scope, role of SSI in economic development, advantages of SSI, steps to start an SSI – Govt policy towards SSI, different policies of SSI, Govt support for SSI during 5 year plans. Impact of Liberalization, privatization, globalization on SSI, effect of WTO/ GATT, supporting agencies of Govt for SSI, meaning; nature of support, objectives, and functions, types of help, ancillary industry and tiny industry (Definition only).Different Schemes, TECKSOK, KIADB, KSSIDC, KSIMC, DIC single window Agency SISI, NSIC, SIDBI, KSFC.

UNIT 5 **[10 hrs]**

PREPARATION OF PROJECT

Meaning of Project; Project Identification Project Selection Project Report, Need and significance of Report, Contents, Formulation Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report, Project Appraisal, Identification of Business Opportunities.Market Feasibility Study,Technical Feasibility study, Financial Feasibility Study & Social Feasibility study.

Course Outcomes:

1. Understand the importance of management and its approaches
2. Explain the role and responsibilities of staff towards organization.
3. Comprehend the quality and characteristics of an entrepreneur.
4. Recognize the importance of Small scale industries in economic development
5. Design, plan and prepare project proposals and reports.

TEXT BOOKS

1. **Principles of Management** by PC Tripati, P N Reddy –Tata Mc Graw Hill, 2008
2. **Dynamics of Entrepreneurial Development & Management** by Vasant Desai Himalaya Publishing House, 3rd edition, 1997
3. **Entrepreneurship Development – Small Business Enterprises** by Poornima M Charanthmath Pearson Education – 2005

REFERENCE BOOKS

1. **Management Fundamentals** by Robert Lusier,– Concepts, Application, Skill Development – Thomson
2. **Entrepreneurship Development** by S S Khanka S Chand & Co
3. **Management** by Stephen Robbins Pearson Education/PHI 17th Edition 2003.
4. **Essentials of Management** by Harold Koonz &Heinz weihrich, Tata McGrawhill publishing Co.Ltd.
5. **Small scale Industries & Entrepreneurship** by Vasanth Desai Himalaya publishing house

Course Title	BIOPROCESS EQUIPMENT DESIGN AND DRAWING										Credits	4		
Course Code	1	0	B	T	6	D	C	E	Q	D	L-T-P	3	1	0

Pre-requisites:
Knowledge of Unit Operations, Enzyme Kinetics and Reaction Engineering, Elements of Engineering Drawing and Elements of Mechanical Engineering

UNIT 1 **[15L+6T]**

INTRODUCTION TO DESIGN

Memory and proportional Drawings

Joints : Flanged pipe joint, Gland & Stuffing box expansion joint.
Pipe fittings : Bend, Elbow, Tee, Cross.
Valves : Ball, Gate, Non return safety
Pumps : Centrifugal Pump

UNIT 2 **[25L+6T]**

PROCESS EQUIPMENT DESIGN

Detailed process and mechanical design of the following equipments
I. Agitated and jacketed vessels
II. Fermentor vessels
III. Shell and tube exchangers

NOTE:
1. Memory drawings: Symbols of equipment used in bioprocessing and sketches of pipe fittings.
2. Proportional Drawings: Process Equipment and Various types of joints and Valves.
3. Drawing through manual drafting and CAED approaches.

Course Outcomes:
1. Identify the various symbols used in process flow diagrams
2. Draw the sketches of pipe joints, stuffing box, valves and pipes
3. Intricately design shell & tube heat exchanger, jacketed & agitated vessel and fermenter for given capacity.

TEXT BOOKS
1. **Process equipment design** by M V Joshi., V.V Mahajani
2. **Principles of fermentation Technology** by P.F. Stanbury and A. Whitaker, Pergamon Press, 1984.

REFERENCE BOOKS
1. **Mechanical equipment design** by Brownell and Young
2. **Principles, process design and Equipment** by H C Vogel, Noyes.
3. **Chemical Engineering** by Coulson and Richardson, Vol. 6, 1993.
4. **Perry's Chemical Engineers' Handbook** by Perry, R.H. Green, D.W. McGraw-Hill. Seventh Edition, 1997.
5. **Unfired pressure vessel** I S Code 2825
6. **Shell and tube heat exchanger specifications**, I S Code 4503

Course Title	ENZYME TECHNOLOGY										Credits	5		
Course Code	1	0	B	T	6	D	C	E	N	T	L-T-P	3	1	1

Pre-requisites:
Knowledge of Basics of Biomolecules, Biochemistry, Molecular Biology, Enzyme Kinetics & Reaction Engineering and Genetic Engineering

PART A: THEORY

UNIT 1 **[6L+2T]**

FUNDAMENTALS OF ENZYME FUNCTION

Introduction to enzymes, remarkable properties of enzymes as catalysts, classification and nomenclature, sources, specificity of enzymes, Extraction of enzymes: Extraction of soluble enzymes and membrane-bound enzymes, nature of extraction medium and conditions of extraction. Purification of enzymes: preliminary and secondary purification procedures, degree of purification and criteria of purity of enzymes, determination of molecular mass of enzymes.

UNIT 2 **[9L+3T]**

BIOCATALYTIC FUNCTIONS

Mechanism of enzyme action: active site, activation energy and the reaction coordinate binding energy contribution to reaction specificity and catalysis. Lock and key model and induced fit hypothesis. Advantages of enzymes vs chemical catalysts, Isolated Enzymes versus whole cell systems, cofactors and coenzymes, catalytic mechanisms: Acid-base catalysis (ribonuclease A), Covalent catalysis (chymotrypsin), Metal ion catalysis (Carbonic anhydrase), catalysis through proximity and orientation effects, Substrate strain (lysozyme) & entropy effects Mechanism of coenzymes (NAD/NADP, FAD/FADH2, PLP, Coenzyme A, TPP, Biotin).

UNIT 3 **[9L+3T]**

ENZYMATIC TECHNIQUES AND ENZYMES OF MEDICAL IMPORTANCE

Enzyme techniques: Enzyme and isoenzyme measurement methods with two examples (fixed incubation and kinetic methods), Methods for investigating the kinetics of Enzyme catalysed reactions – Initial velocity studies, rapid-reaction techniques, Standardization and optimization methods, stability of enzymes.Enzymes of medical importance: Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase and its inhibitors, pseudocholinesterase, glucose-6-phosphate dehydrogenase (GPD), enzyme pattern in diseases likes Myocardial infarctions (SGOT, SGPT & LDH). Isoenzymes (CK, LD, ALP), amylase isoenzymes, use of isozymes as markers in cancer and other diseases, Enzymes in immunoassay techniques, therapeutic enzymes.

UNIT 4 **[9L+3T]**

INDUSTRIAL APPLICATIONS OF ENZYME TECHNOLOGY AND IMMOBILIZATION OF ENZYMES

Industrial applications: Enzymes used in detergents, use of proteases in food, leather and wool industries; methods involved in production of glucose syrup from starch (using starch hydrolyzing enzymes), production of maltose and sucrose, glucose from cellulose, uses of lactase in dairy industry, glucose oxidase and catalase in food industry; Restriction enzymes and DNA ligases. Immobilization of enzymes: Techniques of enzyme immobilization, kinetics of immobilized enzymes, effect of solute, partition &

diffusion on the kinetics of immobilized enzymes, design and configuration of immobilized enzyme reactors, applications of immobilized enzyme technology.

UNIT 5 **[6L+2T]**

ENZYME ENGINEERING

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

Course Outcomes:

1. Distinguish various classes of enzymes, explain isolation, purification and characterization methods.
2. Describe methods in enzyme catalysis.
3. Explain methods of determination of kinetic parameters of enzymes and understand the importance of enzymes as biomarkers.
4. A. Illustrate immobilization techniques and application of immobilized enzymes. B. Summarize the industrial applications of enzymes.
5. Comprehend techniques and applications of solvent systems in enzyme engineering.
6. Conduct experiments on enzyme reaction kinetics.

TEXT BOOKS

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

REFERENCE BOOKS

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

PART B: ENZYME TECHNOLOGY LABORATORY

I Isolation of enzymes

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

II Purification and characterization of enzymes

3. Ammonium sulphate fractionation.
4. Purification of amylase by column chromatography.
5. Determination of molecular mass by gel electrophoresis.

III Enzyme kinetics

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

VI Enzyme technology

11. Immobilization of enzymes by gel entrapment (alginate/ carrageenan).
12. Use of pectinases in fruit juice clarification (apple juice).

VII Reactor Kinetics

13. Determination of order and rate constant in batch reactor.
14. Determination of order and rate constant in a continuous stirred tank reactor.
15. Residence time distribution studies in plug flow reactor.
16. Residence time distribution studies in continuous stirred tank reactor.

TEXT BOOKS

1. **Biochemical Engineering Fundamentals** by Bailey and Ollis, McGraw Hill (2nd Ed.). 1986.
2. **Bioprocess Engineering** by Shule and Kargi Prentice Hall, 1992.

REFERENCE BOOKS

1. **Bioprocess Engineering – Kinetics, Mass Transport, Reactors and Gene Expression** by Wolf R. Vieth, A Wiley – Interscience Publication, 1992.
2. **Chemical Engineering Kinetics** by Smith J.M, McGraw Hill, 3rd Edition, New Delhi, 1981.
3. **Chemical and Catalytic Reactor Engineering** by Carbery J A, McGraw Hill, 1976.
4. **Enzymes in Industry: Production and Applications** by W. Gerhartz (1990), VCH Publishers, New York.
5. **Enzyme Technology** by M.F. Chaplin and C. Bucke, Cambridge University Press, Cambridge, 1990.
6. **Enzymes** by Dixon and Webb. IRL Press.
7. **Principles of Enzymology for technological Applications** by B Heinemann Ltd. Oxford(1993).

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

Pre-requisites:
Knowledge of Cell Biology and Genetics, Molecular Biology, Genetic Engineering, Bioinformatics

UNIT 1 **[05 hrs]**

GENOME ANATOMY

Introduction to 'Genomics', Objectives, need for whole genome sequencing of organisms, Genome sizes and C value paradox, Genetic organization of the genomes of prokaryotes and eukaryote-Human. Organelle genomes-physical features and origin

UNIT 2 **[10 hrs]**

GENOME SEQUENCING

High throughput DNA sequencing techniques: Fluorescent automated method, pyro sequencing, Nano pore and DNA- chip methods. Sequencing simple genomes- approaches to sequencing and sequence alignment. Sequencing large genomes-Prerequisites - Sub division of the genome, need for mapping , Genetic and physical techniques for mapping :Linkage analysis ,Restriction mapping-double digestion, partial digestion , optical mapping , FISH and FISH amplification in mapping ,STS & EST mapping , Hybridization mapping, Sequence alignment of large genomes – directed shotgun approach, clone contig approach

UNIT 3 **[07 hrs]**

GENOME ANALYSIS- I

Genome projects and Databases on *E.coli*, *Plasmodium*, C.elagans, Yeast, *Arabidopsis*, Rice , *Drosophila*, Human genome project, Finding genes in genomes, assigning function to new genes,
Importance of non coding sequences- micro RNAs, Sh RNAs ,PiWi and RNA interference

UNIT 4 **[07 hrs]**

GENOME ANALYSIS-II

Comparative genomics- Molecular markers RFLPs, RAPD, AFLP, SSLP- micro and mini satellite markers, ISSLP, SCARS, FISH DNA amplification markers, SNPs, Marker assisted selection. Methods of measurement of mRNA expression-DNA micro arrays, Non-DNA array hybridization.

UNIT 5 **[10 hrs]**

PROTEOMICS

Introduction to proteomics, Methods of protein isolation, quantification, protein separation in 2-DE, Staining 2-DE gels, Image analysis of 2DE gels, Proteome analysis by stable isotope labeling, Mass spectroscopic analysis of peptides, protein sequence determination by Edman degradation. Protein-protein interactions: Co-immuno precipitation, Y2H and its variants, Protein chips, Plasmon resonance and biosensors

Course Outcomes:

1. Comprehend genetic organization of living organisms and describe prokaryotic, eukaryotic and organelle genomes.

2. Explain principles of high throughput techniques in gene sequencing, and contemporary approaches for genome sequencing.
3. Explain features and role of various non- coding DNAs and RNAs.
4. Describe advanced high throughput techniques for comparative of analysis genomes, transcriptomes and Proteomes.
5. Illustrate methods in proteomic approaches.

TEXT BOOKS

1. **Principles of gene manipulation** by S. B. Primrose, Richard M. Twyman, R. W. Old – 2001.
2. **Genomes** by Brown T A, 2006, Blackwell Science.
3. **Proteomics** by SR Pennington and Dunn MJ

REFERENCE BOOKS

1. **Molecular Biotechnology: Principles and Applications of Recombinant DNA** by Glick, B R, Pasternak .J J, 2003, Third edition, DC ASM Press.
2. **A Primer of Genome Science** by Greg Gibson and Spencer V, Third Edition, Muse,February 2009
3. **Genomics, Proteomics and Bioinformatics** by A. Malcolm Campbell and Laurie J. Heyer, Second edition, published by Cold Spring Harbor Laboratory Press and Benjamin Cummings: 28 February, 2006

Course Title	PHARMACEUTICAL BIOTECHNOLOGY										Credits	3		
Course Code	1	0	B	T	6	D	C	P	B	T	L-T-P	3	0	0

Pre-requisites:
Knowledge of Bioinformatics, Genetic Engineering, Biochemistry, Molecular Biology, Basics of Biomolecules

UNIT 1 **[07 hrs]**

INTRODUCTION AND REGULATORY GUIDELINES IN PHARMACEUTICAL BIOTECHNOLOGY

Introduction and history of the pharmaceutical industry, pharmaceutical products, biopharmaceuticals and pharmaceutical biotechnology, Drug development and Economics, Fundamental principles and practical processes involved in preclinical and early proof-of-concept clinical development of a chemical or biological entity. Regulatory authorities - Quality assurance and regulation. GMP, CGMP, GLP, GCP, TQM, ISO-9000, process validation, pharmacopoeia (IP, USP, BP,EP), regulatory protocols, ICH guidelines, Indian FDA regulations.

UNIT 2 **[07 hrs]**

DRUG MANUFACTURE AND FORMULATION

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

UNIT 3 **[10 hrs]**

DRUG METABOLISM

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

UNIT 4 **[09 hrs]**

TOXICOLOGY AND PHARMOCOLOGY

Toxicology: Basic concepts, mechanism of action of toxins, biotransformation of toxins & their clearance from the body, toxic intermediates, side effect, adverse effect, acute toxicity, chronic toxicity, toxicity testing, mutagenesis and carcinogenicity, Teratogenesis and drug-induced fetal damage, allergic reaction to drugs, First-line of treatment, Antidotes. Pharmocology: Drugs action, general principles - binding of drug molecules to cells, tachyphylaxis and desensitization, molecular aspects- targets for drug, Cellular mechanisms – excitation, contraction, secretion, cell proliferation and apoptosis. Biopharmaceuticals drugs from plants, prokaryote and eukaryote, Bioassay, animal models of disease and drug evaluation.

UNIT 5 **[06 hrs]**

DRUG DISCOVERY AND DEVELOPMENT

Drug discovery pipeline, Hit and lead identification, sources of NCEs, Prototype drug, structure-activity relationship (SAR) and quantitative SAR (QSAR), In-silico drug discovery, Target-structure based drug discovery, Characterization and Bio analytical aspects of recombinant proteins, The preclinical stages, clinical development, commercial aspect, NDE, IND.

Course Outcomes:

1. Understand the drug development process and its economics and various guidelines to be followed for drug development process
2. Comprehend the concepts of tablet manufacturing, formulation, dosage forms and target oriented drug delivery
3. Comprehend the phases of metabolism of drugs and toxicants as well as describe methods involved in pharmacokinetics and pharmacodynamics
4. Apply the concepts of Insilico drug discovery process in discovery of a new drug entity.

TEXT BOOKS

1. **The Theory and Practice of Industrial Pharmacy** by Lachman L, CBS publication.
2. **Essentials of Pharmacotherapeutics** by F.S. K. Barar, CBS Publication.
3. **Pharmaceutical biotechnology** by S. S. Korai, Vallabh Prakashn.
4. **Validation in Manufacturing of Biopharmaceuticals: Guidelines, Current Practices and Industrial Case Studies** by Anurag S. Rathore, Gail SoferProcess CRC press. 2005.
5. **Biopharmaceuticals: Biochemistry and Biotechnology** by Gary Walsh. 1st edn. 2004.

REFERENCE BOOKS

1. **Pharmacology** by Rang H. P, 5th edition,Elsevier publication.
2. **Modern Pharmaceutics** by Banker G. S. 4th edition, Marcel Dekker Publication.
3. **Indian Pharmacopoeia**- Government of India
4. **British Pharmacopoeia**- British Government, United States Pharmacopoeia- Government of USA.
5. **Pharmaceutics** by Aulton
6. **Pharmacokinetics** by Gibaldi M. Marcel Dekker Publication.
7. **Pharmaceutical biotechnology: an introduction for pharmacists and pharmaceutical scientists** by Daan J. A. Crommelin, Taylor & Francis
8. **Pharmaceutical Biotechnology** by Dr. Oliver Kayser, Prof. Dr. Rainer H.Müller
9. **Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes in to Drugs** by Rodney J. Y. Ho, Milo Gibaldi. Contributor Rodney J. Y. Ho, Milo Gibaldi.
10. **Basic and Clinical Pharmacology** by Bartram G. Katzung, McGraw Hill Publications, 2004 (Chapter 5).
11. **Remington: The Science and Practice of pharmacy Volume I** by Alfonso R. Gennaro, Lippincott Williams and Wilkins Publications, Twentieth edition, 2000

Course Title	PROCESS CONTROL & AUTOMATION										Credits	5		
Course Code	1	0	B	T	6	D	C	P	C	A	L-T-P	3	1	1

Pre-requisites:
Knowledge of Unit Operations, Enzyme Kinetics and Reaction Engineering and Biosensors and Bioinstrumentation

PART A: THEORY

UNIT 1 **[8L+2T]**

INTRODUCTION TO BIOPROCESS CONTROL

The Biochemical Process, Typical Industrial Control Problem – Stirred Tank Heater. Variables of a Process, Concept of process Control System, Overview of Control System Design, Historical Overview, Basic Digital computer Architecture, Data Acquisition and control, Process characteristics, Laplace transforms.

UNIT 2 **[9L+2T]**

FIRST ORDER SYSTEMS

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

UNIT 3 **[8L+2T]**

SECOND ORDER SYSTEMS

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

UNIT 4 **[9L+2T]**

CLOSED LOOP CONTROL SYSTEMS

Block diagrams for servo and regulatory problems. Transient response of first and second order processes for set point changes and load changes with proportional and PI controllers, conceptual numericals. Controllers and final control elements - Actuators, Positioners, Valve body, Valve plugs, Characteristics of final control elements, controllers – two position control, proportional control, derivative control, integral control, P-I (proportional-integral) control, P-D (proportional- derivative) control, P-I-D (proportional-integral-derivative) control, conceptual numericals.

UNIT 5 **[8L+2T]**

CONTROLLER DESIGN, BIOPROCESSES DYNAMICS AND CONTROL

Criteria for stability, Routh test; Root locus (basics), Introduction to frequency response, Bode criteria for stability, Nyquist criteria; Conceptual numericals. Dynamics and control of bioreactors & sterilizers. On-line data analysis for state and parameter estimation techniques for biochemical processes.

Course Outcomes:

1. Understand the importance, classification of automatic process control system and solve related problems
2. Deduce transfer function for various systems as well as analyze and interpret the responses
3. Comprehend the working principle of various controllers, final control elements and solve related problems
4. Analyze the stability of system using different tools and techniques
5. Measure and control the various physical parameters using controllers

TEXT BOOKS

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

REFERENCE BOOKS

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

PART B: BIOPROCESS CONTROL & AUTOMATION LAB

1. Characteristics of Transducers (Temperature).
2. Characteristics of Transducers (Pressure).
3. Characteristics of Transducers (Flow).
4. Measurement of OD and DO for microbial cultures
5. Dynamics of First order system (mercury thermometer) for step input and impulse input.
6. Non-interacting system responses to step / pulse input
7. Interacting System responses to step / pulse input
8. Temperature controller – responses to set point / load change
9. pH controller – responses to set point / load change
10. Tuning of Flow controller (ZN and CC methods) and responses of tuned P, PI and PID controllers
11. Tuning of Pressure controller (ZN and CC methods) and responses of tuned P, PI and PID controllers
12. Control of DO (dissolved oxygen level)
13. Control of Agitation (to monitor DO since they are interlinked)

Course Title	ANIMAL BIOTECHNOLOGY										Credits	4		
Course Code	1	0	B	T	6	D	E	A	B	T	L-T-P	4	0	0

Pre-requisites:
Knowledge of Cell Biology, Human Physiology, Basics of Biomolecules , Biochemistry, Bio analytical Techniques, Immunology, Genetic Engg.

UNIT 1 **[11 hrs]**

INTRODUCTION TO ANIMAL TISSUE CULTURE

Introduction, history, scope, advantages & limitations, Laboratory design, layout and equipment: Planning, Construction, layout, essential equipments –CO_2 incubator, inverted stage microscope, culture Vessels (types & designs), principles of sterile techniques, sources of tissue, types of tissue, cryopreservation, Media and reagents: Physicochemical properties, Balanced salt solutions, Complete media, Serum, serum free media, advantage of serum free media, features of MEM, DMEM, RPMI and Ham's medium, role of antibiotics in media.

UNIT 2 **[14 hrs]**

ANIMAL CELL CULTURE

Different tissue culture technology; Primary culture, establishment of primary culture, cell lines- definite and continuous cell lines, nomenclature, subculture and propagation, suspension cultures & anchorage dependent cultures, routine maintenance; Contamination- Source of contamination, Type of microbial contamination, Monitoring, Eradication of contamination, Cross-Contamination ,cell immortalization, Behavior of cells in culture condition- morphology, division & growth. Characterization & Quantitation of cell lines:-Need for characterization, morphology, chromosome analysis, DNA Content, RNA and Protein, Enzyme Activity, Antigenic Markers, Transformation, Immortalization, Aberrant Growth Control, Tumorigenicity, Cell counting, Cell Proliferation, Planting Efficiency, Labeling Index, Generation Time. Cytotoxicity: Introduction, In vitro limitations, Nature of assay, Viability assay, Survival assay, Microtitration assay, Transformation assay Development and maintainance of cell lines: Embryonic & adult (mammalian, Insect cell lines); stem cells.

UNIT 3 **[10 hrs]**

ANIMAL CELL CULTURE APPLICATIONS

Cell cloning and selection; Transfection and transformation of cells; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for in vitro testing of drugs, environmental pollutants; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins, Gene mapping, marker assisted selection and genetic improvement of desired characters of domestic animals. Rapid diagnosis of diseases in live-stock via: RIA, ELISA and PCR.

UNIT 4 **[08 hrs]**

DEVELOPMENT AND USE OF TRANSGENIC ANIMALS

Transgenic animals; Transgenic-mice methodology: Retroviral vector method, DNA microinjection method, Engineered-embryonic stem cell method, Knocking in and knocking out of genes; Applications:

transgenic animals as bioreactors for production of proteins of pharmaceutical value; Ethical issues & legal issues

UNIT 5 **[09 hrs]**

IN VITRO FERTILIZATION AND EMBRYO TRANSFER

Embryo biotechniques for augmentation of reproductive efficiency and faster multiplication of superior germ plasm, super ovulation, oestrus synchronization, embryo collection, evaluation and transfer, Composition of IVF media, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI,MESA, preparation of foster mother, surgical and nonsurgical methods of embryo transfer.

Course Outcomes:

1. Understand the potentials and applications of animal tissue/cell culture and its impact on BT solutions in health and disease.
2. Plan and design layouts of cell culture labs. ,select and relate the usage of suitable equipment , culture vessels and media
3. Describe the various cell culturing techniques and procedures and select the suitable technique.
4. State the different methods used for quantitation and characterization of cells in culture .
5. Describe methods for commercial scale production of animal cells and their products
6. Explain the various procedures in transgenic technologies and their applications
7. Understand the usage of tools and techniques used for augmentation of reproductive efficiencies in human and animals (used for IVF and embryo transfers)

TEXT BOOKS

1. **Culture of Animal Cells** by Freshney R I(2005), 5th Edn, Wiley-Liss.
2. **Animal Cell Biotechnology** by Spier RE and Griffiths JB (1988), Academic Press.

REFERENCE BOOKS

1. **Molecular Biotechnology: Principles and Practices** by Channarayappa (2006). University Press (India) Pvt.Ltd., Worldwide CRC Press.
2. **Molecular Biotechnology** by Primrose
3. **Animal Biotechnology** by Murray Moo- Young (1989), Pergamon Press, Oxford.
4. **Introduction to cell & tissue culture** by Jennie P. Mather & P.E.Robert.

Course Title	METABOLIC ENGINEERING										Credits	4		
Course Code	1	0	B	T	6	D	E	M	T	E	L-T-P	4	0	0

Pre-requisites:
Knowledge of molecular biology, genetic engineering, biochemistry and basic statistics

UNIT 1 **[12 hrs]**

INTRODUCTION AND METABOLIC REGULATION

Introduction: Importance of metabolic engineering and its multidisciplinary nature. Review of cellular metabolism, transport processes, fuelling reactions, biosynthetic reactions, polymerization reactions and energetics

An overview of Cellular Metabolism, Transport Processes, Passive Transport, Facilitated Diffusion, Active Transport, Fueling Reactions, Glycolysis, Fermentative Pathways, TCA Cycle and Oxidative Phosphorylation, Anaplerotic Pathways, Catabolism of Fats, Organic Acids, and Amino Acids, Biosynthetic Reaction, Biosynthesis of Amino Acids, Biosynthesis of Nucleic Acids, Fatty Acids.

UNIT 2 **[12 hrs]**

METABOLIC FLUX AND APPLICATIONS OF METABOLIC FLUX ANALYSIS

Metabolic flux analysis and its application, Methods for experimental determination of metabolic flux by isotope dilution method. Production of Glutamic Acid and regulation by Bacteria, Calculation of Theoretical Yields, Metabolic Flux Analysis of Lysine Biosynthetic Network in C. glutamicum, Metabolic Flux Analysis of Specific Deletion Mutants of C. glutamicum, Metabolic Fluxes in Mammalian Cell Cultures, Determination of Intracellular Fluxes, Validation of Flux Estimates by 13 C Labeling Studies, Application of Flux Analysis to the Design of Cell Culture Media.

UNIT 3 **[08 hrs]**

REGULATION OF METABOLIC PATHWAYS

Regulation of Enzymatic Activity, Overview of Enzyme Kinetics, Simple Reversible Inhibition Systems, Irreversible Inhibition, Allosteric Enzymes: Cooperativity, Regulation of Enzyme Concentration, Control of Transcription Initiation, Control of Translation, Global Control: Regulation at the Whole Cell Level, Regulation of Metabolic Networks, Branch Point Classification, Coupled Reactions and the Role of Global Currency Metabolites.

UNIT 4 **[10 hrs]**

METABOLIC ENGINEERING IN PRACTICE

Enhancement of Product Yield and Productivity, Ethanol, Amino Acids, Solvents, Extension of Substrate Range, Metabolic Engineering of Pentose Metabolism for Ethanol Production, Cellulose-Hemicellulose Depolymerization, Lactose and Whey Utilization, Sucrose Utilization, Starch Degrading Microorganisms, Extension of Product Spectrum and Novel Products, Antibiotics, Polyketides, Vitamins, Biopolymers, Biological Pigments, Hydrogen, Pentoses: Xylitol, Improvement of Cellular Properties, Prevention of Overflow Metabolism, Alteration of Substrate Uptake, Maintenance of Genetic Stability.

UNIT 5 **[10 hrs]**

BIOSYNTHESIS OF METABOLITES AND BIOCONVERSIONS

Primary metabolites: Alteration of feedback regulation, limiting of accumulation of end products, resistant mutants. Secondary metabolites: Precursor effects, prophage, idiophase relationship, enzyme induction,

feedback repression, catabolic repression, important groups of secondary metabolic enzymes, phosphotransferase, ligases oxido reductases, oxygenases, carboxylases.Advantages of bioconversions, specificity, yields. Factors important to bioconversions, regulation of enzyme synthesis, permeability co metabolism, conversion of insoluble substrates.

Course Outcomes:

1. Apply the concepts of metabolic pathway in release of desired products.
2. Understand the importance of mfa and solve problems of biosynthetic network
3. Describe the regulation of metabolic pathway at cellular and molecular level

TEXT BOOKS

1. **Metabolic Engineering – Principles and Methodologies** by Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen.
2. **Principle of Fermentation Technology** by P.F. Stanbury and A. Whitkar, Pergammon press.
3. **Scale-up Methods in Chemical Engineering** by Johnson and Thrins.

REFERENCE BOOKS

1. **Bioprocess engineering basic concepts** by M.L. Shuler and Kargi.
2. **Control of metabolic process** by A.C. Bowden and M.L. Cardens, Plenum Publisher.
3. **Fermentation and enzyme Technology** by Wang D I C Cooney C I Demain, A L John Willey
4. **Metabolism of Agrochemicals in Plants** by T. Roberts, Willey Int.
5. **Biochemistry** by Zubey. G, McMillan publications.

Course Title	PLANT BIOTECHNOLOGY										Credits	4		
Course Code	1	0	B	T	6	D	E	P	B	T	L-T-P	4	0	0

Pre-requisites:
Knowledge of Cell Biology, Human Physiology, Biochemistry, molecular biology, Industrial Biotechnology and Genetic Engineering.

UNIT 1 **[11 hrs]**

INTRODUCTION AND PLANT GENETIC ENGINEERING

Introduction-: Invitro culture of plant cells **(**Cell, Tissue and organ culture), tissue culture media (composition and preparation), organogenesis, somatic embryogenesis, embryo culture. Plant Genetic Engineering: Types of plant vectors and their use - Ti and Ri-plasmids as vectors. Viruses as a tool to delivery foreign DNA, Screening and selection of transformants – PCR and hybridization methods, mechanism of transgene interaction - Transgene stability and gene silencing, generation and maintenance of transgenic plants.

UNIT 2 **[12 hrs]**

PLANTS FOR BIOTIC AND ABIOTIC STRESSES

Biotic stresses-introduction,types and application of plant transformation – Bacillus thuringiensis and inclusion bodies, Structure and functions of Cry proteins – mechanism of action, critical evaluation and current status of Bt plants. Non-bt approaches-protease inhibitors, alpha amylase inhibitor and others.Transgenic technology for development of virus, bacterial and fungal resistance plants (with gene constructs. Abiotic stresses – Introduction to drought and salinity stresses, transgenic strategies for development of drought resistant plants, case studies. Post-harvest losses, long shelf life of fruits and flowers, use of ACC synthase, polygalacturanase, ACC oxidase, male sterile lines, barstar and barnase systems. Herbicide resistance - phosphoinothricin, glyphosate, atrazine; insect resistance. Biosafety regulations and evaluation of transgenics contained conditions. Implications of gene patents.

UNIT 3 **[08 hrs]**

MOLECULAR FARMING AND APPLICATIONS

Plant metabolic engineering and industrial products: Molecular farming for the production of industrial enzymes, biodegradable plastics, polyhydroxybutyrate, antibodies, and edible vaccines. Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc., Engineering of carotenoid and provitamin biosynthetic pathways.

UNIT 4 **[12 hrs]**

NITROGEN FIXATION AND SIGNAL TRANSDUCTION IN PLANTS

Nitrogen fixation and biofertilizers - Diazotrophic microorganisms, nitrogen fixation genes. Two component regulatory mechanisms. Transfer of *nif* genes and *nod* genes – structure, function and role in nodulation; Hydrogenase - Hydrogen metabolism. Genetic engineering of hydrogenase genes.Signal transduction in plants- mechanism, plant hormone signaling, transduction, light perception and signaling network in higher plants, calcium signaling, sphingolipids in plant signaling.

UNIT 5 **[09 hrs]**

ALGAL TECHNOLOGIES

Blue-green algae and Azolla - Identification of elite species and mass production for practical application. Mycorrhizae - importance in agriculture and forestry. Algae as a source of food, feed, single cell protein, biofertilizers; industrial uses of algae. Mass cultivation of commercially valuable marine macro algae for agar agar, alginates and other products of commerce and their uses. Mass cultivation of microalgae as a source of protein and feed.

Course Outcomes:

1. Describe the various plant cell culturing techniques and procedures
2. Understand the role of plant genetic engineering in biotic and abiotic stresses
3. Identify the potentials and applications of plant metabolic engineering.
4. Comprehend the importance of nitrogen fixation and signal transduction in plants
5. Explain the technologies involved in Algal cultivation and applications.

TEXT BOOKS

1. **Plant Biotechnology** by Slater and Scott, 2nd edition –For unit 2 & 3
2. **Molecular Biotechnology** by Glick and Pasternick- For unit 1&4
3. **Plant biotechnology** in Agriculture by K. Lindsey and M.G.K. Jones (1990), Prentice hall, New Jersey.
4. **Biotechnology in Crop Improvement** by HS Chawla. Intl Book Distributing Company, 1998.
5. **Biodegradation and Detoxification of Environmental Pollutants** by Chakrabarthy AM.
6. **Practical Application of Plant Molecular Biology** by RJ Henry. Chapman and Hall 1997.

REFERENCE BOOKS

1. **Molecular Biotechnology: Principles and Practices** by Channarayappa, 2006, University Press.
2. **Plant Tissue Culture: Applications and Limitations** by S.S. Bhojwani (1990), Elsevier, Amsterdam.
3. **Plant Cell and Tissue Culture for the Production of Food Ingredients** by TJ Fu, G Singh and WR Curtis. Kluwer Academic Press, 1999.
4. **Biotechnology in Agriculture** by MS Swamynathan, McMillian India Ltd.
5. **Gene Transfer to Plants** by Polyykus I and Spongernberg, G.Ed. Springer Scam 1995.
6. **Genetic Engineering with Plant Viruses** by T Michael, A Wilson and JW Davis, CRC Press 1992.
7. **Molecular Approaches to Crop Improvement** by Dennis Liwelly Eds 1991.
8. **Plant Cell and Tissue Culture-A Laboratory manual** by Reinert J and Yeoman MM, Springer 1994.
9. **Plant Tissue Culture** by Sathyanarayana BN (2007) IK INTL publishers

Course Title	RESEARCH METHODOLOGY										Credits	4		
Course Code	1	0	B	T	6	D	E	R	M	D	L-T-P	4	0	0

Pre-requisites:
Knowledge of Statistics, Mathematics and English.

UNIT 1 **[11 hrs]**
INTRODUCTION
Meaning and objectives of research, motivation in research, writing strategies, ethical consideration, review of literature, types of research, research approaches, significance of research, research methods v/s methodology, research and scientific method, research process, criteria for good research, problems encountered by researchers in India, .

UNIT 2 **[10 hrs]**
RESEARCH DESIGN
Meaning of research design, need of research design, functions of research design, purpose and Principles, features of good design, Types of Research Design, basic principles of experimental design, design of experiments.

UNIT 3 **[10 hrs]**
DATA COLLECTION
Types of data, methods and techniques of data collection, primary and secondary data, meta analysis, historical methods, content analysis, devices used in data collection, pilot study and pretest of tools, choice of data collection methods, thorough description of methods of data gathering and sources. Analytical Techniques – detailed discussion of data gathering and analytical methods, including explanation of their suitability of these techniques compared with others and any possible problems arising from the methods selected.

UNIT 4 **[11 hrs]**
PROCESSING AND ANALYSIS OF DATA
Use of statistics for data analysis, measures of central tendency, dispersion, skewness and relationship, sampling distributions, sampling theory, determination of sample size, displaying data-tables (types of table), graphs- histogram, bar chart, frequency polygon, pie charts, trend curve, scattergram, chi square test, analysis of variance, multiple regression analysis, preparation of tables, scaling Techniques - graphic and diagrammatic representation of data, role of computers in research.

UNIT 5 **[10 hrs]**
INTRPRETATION AND REPORT WRITING
Techniques of interpretation, precautions in interpretations, significance of report writing, different steps in report writing, layout of research report, mechanics of writing research report, issues related to plagiarism, copyright laws, acknowledging the sources, documentation, organization of reference material, bibliography and end note.

Course Outcomes:

1. Understand how scientific research is conducted.
2. Design methodology for research.
3. Comprehend the methods and techniques involved in Data collection
4. Apply the basic statistics to test the significance, validity and reliability of the research results.
5. Interpret the research results and prepare report.

TEXT BOOKS

1. **Research Methodology – Methods and Techniques** by Kothari, C.R, New Age International Publishers, New Delhi, 2007.
2. **Research Methodology** by Ranjith Kumar, New Age International Publishers, New Delhi

REFERENCE BOOKS

1. **Marketing Research, Text and cases** by Boyd, Westfall and Stouch, All India Travel Book Sellers, New Delhi, 2005.
2. **Research Methods** by Brayman, Oxford University Press, New Delhi, 2005.
3. **Methodology of Research in Social Sciences** by Krishnaswami, O.R, Himalaya Publishing House, Mumbai, 2006.
4. **Research Methodology** by R.Pannersalvem**,** Prentice-hall of India Pvt. Ltd, New Delhi, 2004.
5. **Research Methodology in Behavioral Science** by R.S. Dwivedi, Macmillan India ltd, New Delhi, 2005.
6. **Research methodology in the medical and biological sciences** by Petter Laake, edited by Bjorn Olsen, Haakon benestad, Elsevier Publications.
7. **Qualitative, Quantitative and Mixed method approaches** by John. W. Creswell, Research Design, Second Edition.

Course Title	UPSTREAM PROCESS TECHNOLOGY										Credits	5		
Course Code	1	1	B	T	7	D	C	U	P	T	L-T-P	3	1	1

Pre-requisites:
Knowledge of Microbiology, Genetic Engineering, Enzyme kinetics and reaction engineering, Plant biotechnology, Animal biotechnology, Metabolic Engineering, Bioprocess Equipment design and drawing, Immunotechnology, Fermentation technology and Downstream processing

PART A – THEORY + TUTORIAL

UNIT 1 **[10L+2T]**

PLANT CELL AND TISSUE CULTURE TECHNIQUES

Plant Cell Culture: Introduction, Requirements, Techniques, Media Constituents & Selection. Cellular Totipotency & Applications, Organogenic Differentiation, Cyto-differentiation, Somatic Embryogenesis - Induction, Development and Maturation of Somatic Embryos, Large Scale Production of Somatic Embryos, Synthetic Seeds, Androgenesis & Gynogenesis – Techniques for Production of Haploids, Diploidation & its Applications, Triploid Production (Endosperm Culture) & its Applications.

UNIT 2 **[6L+2T]**

METABOLITE PRODUCTION

Production of Secondary Metabolites, Immobilization Strategies, Biotransformation, Hairy-root Culture, Bioreactor & Bioprocess Considerations in Plant Secondary Metabolite Production, Search and Discovery of Novel Microbial Secondary Metabolites, Production of Primary Metabolites.

UNIT 3 **[10L+2T]**

ANIMAL CELL CULTURE TECHNIQUES AND HYBRIDOMA TECHNOLOGY

Introduction, Requirements for animal cell culture laboratory, Equipment and Apparatus, Sterilization of Equipment and Apparatus. Media for Culturing Animal Cells and Tissues; Natural and Synthetic Media. Preparation, Sterilization and Storage of Media. Bioreactor considerations for Animal Cell Cultures, Short-term Lymphocyte Culture, Fibroblast Cultures from Chick Embryo, Development and Maintenance of Cell lines, Hybridoma and Monoclonal Antibody Production, *In vitro* culture of Oocytes/Embryos, Cell/Embryo cryopreservation, Stem cell isolation and culture.

UNIT 4 **[8L+2T]**

MICROBIAL CELL CULTURE TECHNIQUES

Media Preparation and Sterilization, Culture maintenance. Isolation of Pure-Colonies, Bacterial titre estimation, Growth Curve, Culture Characterization, Auxotroph Culture. Biochemical Characterization, Antibiotic Sensitivity, Bacterial Recombination, Replica Plating Technique, Industrial Applications - Use of microbes in industrial waste treatment, Nutrient cycling and Microbial Metal Mining, Utilizing genetically engineered organism for bioprocessing.

UNIT 5 **[8L+2T]**

FERMENTATION TECHNOLOGY

Introduction, Media Constituents (Water, Energy sources, Carbon sources, Nitrogen sources, Minerals-Chelators, Growth factors, buffers, precursors and metabolic regulators, oxygen and antifoams),Media Selection and Preparation, Sterilization of Media; Filter Sterilization, Media optimization, Optimization of Fermentation Process - Physiological and Genetic Strategies, Strategies to optimize product yield; Long, Medium and Short term Storage of Microbial Products, Antibiotic Production with the help of process flow charts, Improvement of existing Classes of Antibiotics, Microbiology of brewing.

Course Outcomes:

1. Describe the requirements and techniques of plant tissue culture.
2. Explain bioreactor and bioprocess considerations for the production of important metabolites.
3. Comprehend the requirements and techniques involved in animal cell culture.
4. Outline the techniques involved in culturing and applications of microorganisms.
5. Describe the requirements of fermentation and strategies of product optimization.
6. Demonstrate production of industrially important metabolites.

TEXT BOOKS

1. **Plant tissue Culture: Theory and Practice** by S.S. Bhojwani and M.K. Razdan (1996)
2. Elsevier, Amsterdam
3. **Animal cell culture Techniques** by Ian Freshney.
4. **Principles of fermentation Technology** by P.F. Stanbury and A. Whitaker, Pergamon Press, 1984.
5. Microbial Biotechnology by Alexander N Glazer, Hiroshi Nikaido, W H Freeman & Company New York.

REFERENCE BOOKS

1. **Plant Cell Culture: A Practical Approach** by R.A. Dixon & Gonzales, IRL Press.
2. **Animal Biotechnology** by Murray Moo-Young (1989), Pergamon Press, Oxford

PART B – UPSTREAM PROCESS TECHNOLOGY LABORATORY (2 HOURS/WEEK)

1. Estimation of anthocyanin from leaf
2. Estimation of lycopene from tomato fruits.
3. Comparison of yields-shake flasks and fermenter for production of citric acid/glucose isomerase
4. Preparation of a fermenter
5. Production of ethanol in a fermenter and Estimation of ethanol from fermented broth
6. Production of α amylase by batch fermentation
7. Immobilization of whole cells by gel entrapment method
8. Production of penicillin and assessment of yield
9. Callus induction
10. Development of suspension cultures from callus
11. Induction of secondary metabolite

TEXT / REFERENCE BOOKS

1. **Lab Manual** by Faculty

Course Title	FERMENTATION TECHNOLOGY AND DOWNSTREAM PROCESSING										Credits	5		
Course Code	1	1	B	T	7	D	C	D	S	P	L-T-P	3	1	1

Pre-requisites:
Knowledge of Microbiology, Genetic engineering, Bio analytical techniques, Unit operations, process control and automation, bioprocess equipment design and drawing, enzyme kinetics and reaction engineering.

PART A– THEORY + TUTORIAL

UNIT 1 **[6L+2T]**

INTRODUCTION TO FERMENTATION TECHNIQUES

The Range of Fermentation processes, industrially important microorganisms, Isolation and Strain improvement, Development of inoculum for the industrial fermentations.

UNIT 2 **[10L+2T]**

DESIGN OF FERMENTERS

Functional requirements of Fermenters and Basic design, Types of Fermenters, Aseptic operation and Containment: Design of batch sterilization process-calculation of the Del factor during heating and cooling, calculation of the holding time at constant temperature, Richard's rapid method for the design of sterilization cycles, the scale up of batch sterilization processes, methods of batch sterilization; design of continuous sterilization processes, sterilization of the fermenter, Maintenance of aseptic condition, Aeration and Agitation: Types of Spargers, kla value and Rheology; Instrumentation and Control of various operational parameters (pH, Temperature, Pressure, Agitation, Antifoam, P_{O2}).

UNIT 3 **[10L+2T]**

IMPORTANCE OF DOWNSTREAM PROCESS TECHNOLOGY AND PRIMARY SEPARATION TECHNIQUES

Role and importance of downstream processing in biotechnological processes. Problems and Requirements of byproduct purification. Economics and downstream processing in Biotechnology. Cost cutting strategies, characteristics of biological mixtures, process design Criteria for various classes of byproducts (high volume, low value products and low volume, high Value products), physicochemical basis of bio separation processes; Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques; Flocculation and Sedimentation, Centrifugation and Filtration methods.

UNIT 4 **[8L+2T]**

MEMBRANE SCIENCE AND TECHNOLOGY AND ENRICHMENT OPERATIONS

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

organic solvents, and polymers, extractive separations. Aqueous two-phase extraction, supercritical extraction; Insitu product removal/integrated bioprocessing.

UNIT 5 **[8L+2T]**

SECONDARY PRODUCT SEPARATION TECHNIQUES AND PRODUCT RECOVERY:

Distillation, Liquid - liquid extraction, Absorption and Adsorption, Crystallization, Centrifugation, Ultra Centrifugation, differential centrifugation, Dialysis, Salt Fractionation (Precipitation with Ammonium sulphate). Radio immuno Assay - Principle and applications; Review of Product Recovery Techniques.

Course Outcomes:

1. Explain the fermentation process, inoculum development and strain improvement techniques.
2. Compare the various types of fermenters and their applications.
3. Describe various sterilization techniques, write formulae & processes for batch and continuous sterilization.
4. Describe the various methods of product isolation, separation and purification.
5. Conduct experiments on isolation, separation & purification of bio - products.

TEXT BOOKS

1. **Principles of Fermentation Technology** by P.F. Stanbury, A. Whitkar and S.J. Hall, 1997, Aditya Book, New Delhi.
2. **Enzymes and fermentation** by Banks. G.T., 1996.
3. **Bioseparation – Downstream processing for biotechnology** by Belter P.A., Cussier E. and Wei Shan Hu., Wiley Interscience Pub, 1988.
4. **Separation Processes in Biotechnology** by Asenjo J. and Dekker M, 1993.
5. **Bioseparations** by Belter P.A. and Cussier E., Wiley, 1985.
6. **Product Recovery in Bioprocess Technology - BIOTOL Series**, VCH, 1990
7. **Fermentation & Enzyme Technology** by D.I.C. Wang et.al, Wiley Eastern 1979.
8. **Purifying Proteins for Proteomics** by Richard J Simpson, IK International, 2004
9. **Proteins and Proteomics** by Richard J Simpson, IK International, 2003

REFERENCE BOOKS

1. **Biochemical Engineering** by Bailey and Ollis, McGraw Hill Publisher.
2. **Fermentation advances** by Perlman. D (Ed), Aca press, New York.
3. **Bioprocess Engineering** by Shuler and Kargi Prentice Hall, 1992.
4. **Rate controlled separations** by Wankat P.C., Elsevier, 1990
5. **Bioprocess Engineering – Kinetics, Mass Transport, Reactors and** Gene by Wolf R. Vieth
6. **Expression.** A Wiley – Interscience Publication, 1992.
7. **Enzymes in Industry: Production and Applications** by W. Gerhartz (1990), VCH Publishers, New York.
8. **Enzyme Technology** by M.F. Chaplin and C. Bucke, Cambridge University Press, Cambridge, 1990.

PART B – DOWNSTREAM PROCESSING LABORATORY

1. Cell disruption techniques
2. Solid – Liquid separation methods: Filtration
3. Solid – Liquid separation methods: Sedimentation

4. Solid – Liquid separation methods: Centrifugation
5. Product enrichment operations: Precipitation – $(NH4)_2SO_4$ fractionation of a protein
6. Product enrichment operations: Liquid – Liquid extraction
7. Product drying techniques
8. Separation of Amino acids / Carbohydrates by TLC
9. Estimation of Ethanol from fermented broth
10. Estimation of Citric acid from fermented broth
11. Analysis of biomolecules by HPLC/GC (using standard spectra)

TEXT BOOKS/REFERENCE BOOKS

1. **Lab Manual** by Faculty

Course Title	PROCESS PLANT DESIGN & ECONOMICS										Credits	3		
Course Code	1	1	B	T	7	D	C	P	P	E	L-T-P	3	0	0

Pre-requisites:
Knowledge of Unit Operations, Enzyme Kinetics and Reaction Engineering, Bioprocess Equipment Design & Drawing and Process control & automation

UNIT 1 **[07hrs]**
DESIGN CONCEPTS
Introduction, stages of process development, Process Design development. General design considerations, Evaluation of technologies, Feasibility study formats, Plant location and site selection, Plant layout.

UNIT 2 **[08 hrs]**
PROJECT COSTING
Cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of fixed capital investments, cost indices, cost factors in capital investment, Organizations for presenting capital investments, working capital and it's determinants, means of financing.

UNIT 3 **[07 hrs]**
PRODUCTION COST
Estimation of direct costs of production, fixed charges, plant overhead costs, indirect components of cost of production, total cost of production, Break even analysis.

UNIT 4 **[10 hrs]**
INTEREST AND DEPRECIATION
Interest and investment cost, type interest, nominal and effective interest rates, continuous interest, present worth and discount annuities, cost due interest on investment, source of capital. Taxes and insurances. Types of depreciation, services life, salvage value; present value, methods for determining depreciation, single unit and group depreciation.

UNIT 5 **[07 hrs]**
PROFITABILITY ANALYSIS
Profitability: alternative investments and replacements, profitability standards, discounted cash flow, capitalized cost, pay out period ,alternative investments, incremental and replacements.

Course Outcomes:
1. Select suitable site, plant lay out and technologies required for establishment of a process plant
2. Emphasize on the role of process engineer and check the feasibility of process
3. Estimate the cash flow in industrial operations and production cost
4. Estimate interest and depreciation charges on the process
5. Select suitable process by applying profitability analysis

TEXT BOOKS

1. **Plant Design and Economics for Chemical Engineering** by M.S. Peters and K.D.Timmerhaus, Mc Graw Hill, 4th Ed., 1991.

REFERENCE BOOKS

1. **Process Engineering Economics** by Schweyer.

Course Title	HEALTH DIAGNOSTICS AND CLINICAL BIOTECHNOLOGY										Credits	3		
Course Code	1	1	B	T	7	D	E	H	D	C	L-T-P	3	0	0

Pre-requisites:
Knowledge of Genetics, Human Physiology, Biochemistry ,Bio analytical Techniques, Immunology, Biosensors and Bioinstrumentation

UNIT 1 **[10 hrs]**

MOLECULAR DIAGNOSTICS

Disorders and diseases: Metabolic disorders and infectious diseases. Classification and examples under each type. (biochemical & immunological; IEM`s & manifestations; Mendelian & Non-Mendelian; Chromosomal, Mitochondrial, Single gene & single cell disorders; microbial, parasitic & viral infections. Karyotyping analysis and banding techniques. (G-banding, R banding, Q&C banding)-Applications in the cytogenetic analysis of constitutional &hematological disorders; In *situ* hybridization and FISH (FISH, M-FISH & on-FISH)-applications in the cytogenetic analysis of constitutional disorders and chromosomal abnormalities in tumors. Spectral Karyotyping, Comparative genomic hybridization (CGH) & Array based CGH-applications in the analysis of chromosomal abnormalities in tumors; Amplification refractory mutation systems (ARMS); Ligation chain reaction based diagnostics for detection of infectious and genetic diseases. Molecular beacons and quenchers - application in diagnostics.

UNIT 2 **[08 hrs]**

BIOCHEMICAL DIAGNOSTICS

Inborn errors of metabolism lysosomal storage disorders: mucopoylsaccharidoses, amino acid disorders; carbohydrate disorders-Diabetes: Glycogen storage disorders; haemoglobinopathies; Analytical and diagnostic enzymology ,lipids, lipid profile ,measurement and clinical significance.

UNIT 3 **[06 hrs]**

IMMUNODIAGNOSTICS

Introduction to immunodiagnostics; cytokine assays-clinical significance. Serological diagnosis of infectious diseases (types –e.g. autoimmunodiseases)**.** Laboratory methods for diagnosis of parasitic, viral diseases and bacterial diseases. Ribotyping in clinical microbiology.

UNIT 4 **[07hrs]**

CLINICAL RESEARCH

The philosophy behind and organization of clinical research. Disease target identification and selection, receptor-based approaches, agonists, antagonists, enzyme inhibitors, Pre-clinical development to support testing in humans: In vitro and in vivo testing of new compounds [preclinical and clinical trials], Concepts of pharmacovigilance. General principles and guide to data sources, types of epidemiology study designs, ecological (correlation) studies, prevalence surveys or cross-sectional studies, case control studies. Clinical trials-informed consent, placebo responses; Clinical Data Management; Clinical Research from Pharmaceutical Industry Perspective.

UNIT 5 **[08hrs]**

BIOTHERAPEUTICS

Therapeutics: Clinical importance of Proteins (antibodies and enzymes), Hormones and Growth Factors used as therapeutics (erythropoietin & insulin as examples). Interferons, Interleukins and additional Regulatory Factors; Nucleic Acids, Abzymes, iRNA and SiRNA; Preservation and clinical use of blood and blood components, principles and safety guide lines for blood transfusion. Stem cells: Introduction to Stem Cell Biology, stem cell in Tissue engineering.

Course Outcomes:

1. a) Identify the characteristics of some genetic, metabolic, immunological disorders.
   b) Describe various disease diagnostic methods
2. Understand principles of clinical research procedures, drug testing, clinical trials and pharma covigilance
3. Explain requirements for starting up of diagnostic and imaging services.
4. Have knowledge on the contemporary applications of bio therapeutics.

TEXTBOOKS

1. **Medical Biomethods handbook** by John M.Walker & Ralph Rapley, Humana Press.
2. **Tietz Textbook of Clinical Chemistry and Molecular Diagnosis** by Carl A. Burtis, Edward R. Ashwood, David E.Bruns – Elsevier
3. **Balley & Scott's Diagnostic Microbiology** by B.A.Forbes, Daniel F.S and Alcie S.W.-Mosby Elsevier

REFERENCE BOOKS

1. **Essentials of Diagnostic Microbiology** by Lisa Anne Shimeld, Delmer publishers Int. Thomson Publishing Co.
2. **The Science of Laboratory Diagnosis** by Crocker Burnett, John Wiley and Sons Ltd.

Course title	MICROARRAY TECHNOLOGY										Credits	3		
Course Code	1	1	B	T	7	D	E	M	A	T	L-T-P	3	0	0

Pre-requisites:
Knowledge of Bioinformatics, Genomics and Proteomics, Biostatistics, Basics of Computer applications

UNIT 1 **[06 hrs]**

MICROARRAY PREPARATION AND USE OF DATABASES

Introduction, Making Microarrays, Robotic spotting and in-situ synthesis. Spotted Microarrays, In-Situ Synthesised Oligonucleotide Arrays.
Using microarrays: Sample Preparation and Labeling, Hybridization, Washing, Image Acquisition.

UNIT 2 **[11 hrs]**

COMPUTER DESIGN OF OLIGONUCLEOTIDE PROBES AND IMAGE PROCESSING

Oligonucleotide probe, designing of oligonucleotide probe , the filtering of low-complexity sequence, repeat masker, prediction of cross-hybridization to related genes, the thermodynamics of nucleic acid duplexes and the prediction of melting temperature, base-stacking and initiation parameters, adjustments for salt concentrations, probe secondary structure, computation of probe secondary structure. Feature extraction, identifying the Positions of the Features, Identifying the Pixels That Comprise the Features, Identifying the Background Pixels, Calculation of Numerical Information

UNIT 3 **[06 hrs]**

NORMALIZATION

Data Cleaning and Transformation, Within-Array normalization: Linear regression of Cy5 against Cy3, Linear regression of log ratio against average intensity, Non-linear (Loess) regression of log ratio against average intensity, two -dimensional Loess regression, Block-by-block Loess regression, Between-Array normalization, visualizing the Data: Box Plots.

UNIT 4 **[07 hrs]**

MEASURING AND QUANTIFYING MICROARRAY VARIABILITY

Calibration Experiments, Pilot Studies, Quantifying the Variabilities, Log-Normal Distribution, Method for Measuring Variability, Variation Between Replicate Features on an Array, Variability Between the Cy3 and Cy5 Channels, Variability Between Hybridizations to Different Arrays, Variability Between Individuals

UNIT 5 **[09 hrs]**

ANALYSIS OF RELATIONSHIPS BETWEEN GENES, TISSUES OR TREATMENTS

Similarity of Gene Or Sample Profiles, Features of a Distance Measure, Correlation Coefficient, Spearman Correlation, Euclidean Distance, Dimensionality reduction, Principal Component Analysis, Multidimensional Scaling, Hierarchical Clustering, Linkage Methods, Distance Measures, the reliability and robustness of Hierarchical clustering, machine-learning methods for Cluster analysis, K-Means Clustering, Self-Organized Maps.

Course Outcomes:

1. Understand the principle and concepts of microarrays and will apply for designing a microarray experiment
2. Design Oligonucleotide probes and describe microarray image processing to extract numerical information
3. Normalize the data and remove noisy data
4. Quantify the variabilities among features, arrays as well as individual samples
5. Analyze and interpret the relationships between Genes, Tissues or Treatments

TEXT BOOKS

1. **Microarray Bioinformatics** by Dov Stekel, Cambridge University Press, Ed 2003

REFERENCE BOOKS

1. **Microarray analysis** by Mark Schena ,A JOHN WILEY and sons, inc., publications, Ed 2003

Course Title	INTELLECTUAL PROPERTY RIGHTS										Credits	3		
Course Code	1	1	B	T	7	D	E	I	P	R	L-T-P	3	0	0

Pre-requisites:
Knowledge of Constitution of India, Microbiology, Genetic engineering, Pharamceutical BT, Animal BT, plant BT,

UNIT 1 **[06 hrs]**

IPR

Introduction to IPR, Concept of Property, Marx's theory on Property, Constitutional aspects of Intellectual property. Basic principles of Patent laws: Historical background in UK, US and India. Basis for IP protection. Criteria for patentability: Novelty, Utility, and Inventive step, Non obviousness, Non patentable invention.

UNIT 2 **[06 hrs]**

CONVENTIONS & AGREEMENTS

Paris convention (1883), Berne convention for protection of literary and artistic works (1886), Patent Corporation Treaty (PCT), Madrid agreement (1891) and protocols of relative agreement 1989). Rome convention (1961) on the protection of performances, producers of phonograms and Broadcasting organization, TRIPS agreement (1994), WIPO performance and phonograms Treaty (WPPT, 1996).

UNIT 3 **[07 hrs]**

PATENTS

Definition and objectives, Criteria of patenting, Assignment of Patent rights- compulsory license, TRIPS agreement and compulsory licensing, Indian law on compulsory licensing. Infringement of patents- Law enforcing and relevant BT case studies in United Kingdom, United States and India. Infringement defenses with case studies. Benefits of patent grants.

UNIT 4 **[10 hrs]**

IPR IN BIOTECHNOLOGY

Objectives, Evolution of Biotechnology, Application of Biotechnology, Commercial potential of BT invention, R & D investments, Rationale and applications. Concept of Novelty and Inventive step in BT, Microorganisms and BT inventions, Moral issues in patenting BT invention. Substantiation of Patent laws & international agreements related to pharma, microbial, environmental, and agricultural and informatics sectors via classical case studies.

UNIT 5 **[10 hrs]**

TRADITIONAL KNOWLEDGE

Introduction, Justification for plant variety protection, International position, UPOV, 1961, 1978, 1991 guidelines, Plant variety protection in India. Justification for geographical indications, Multi-lateral treaties. Concept of Traditional knowledge, stake holders, issues concerning traditional knowledge, Bioprospecting & Biopyracy – ways to tackle, Protectability of traditional knowledge under existing IP

framework, need for sui-generis regime, Traditional knowledge on the International arena, Traditional knowledge at WTO and National level, Traditional knowledge digital library.

Course Outcomes:

1. Understand IP laws that directly affect the creation, transfer, and licensing of IP with specific reference to patenting issues in biotechnology and pharmaceuticals fields
2. Understand the International Agreements pertaining to IP protection and relate them to the current issues
3. Comprehend the importance of IP protection for biotechnology and other emerging fields highlighting the conflict of interest in the developing and developed world
4. Elaborate on the traditional knowledge, geographical indicators and farmers' rights catering to the development of nation's economy

TEXT BOOKS

1. **Basic Principles and Acquisition of IPR** by Dr. T. Ramakrishna, NLSIU, Bangalore.
2. **Ownership and enforcement of IPR** by Dr. T. Ramakrishna, NLSIU, Bangalore.
3. **Biotechnology and IPR** by Dr. T. Ramakrishna, NLSIU, Bangalore.
4. **The Law & Strategy of Biotechnology Patents** by Sibley Kenneth.
5. **Intellectual Property** by Bently, Lionel, Oxford University Press, 2001.
6. **Cases and Materials on Intellectual Property** by Cornish, W R, 3rd Ed., 1999.

REFERENCE BOOKS

1. **Law relating to Intellectual property** by Dr. B.L. Wadehra, 4th edition Universal law publishing, 2007.
2. **Intellectual Property and Criminal Law, Bangalore** by Gopalakrishnan. N S, National Law School of India Univeristy, 1994.
3. **Intellectual Property Law** by Tina Gart and Linda Fazzani, London, McMillan Publishing Co., 1997.
4. **Intellectual Property Rights in the WTO and developing country** by Watal Jayashree, Oxford University Press, 2001.

Course Title	DAIRY BIO-TECHNOLOGY										Credits	3		
Course Code	1	1	B	T	7	D	E	D	B	T	L-T-P	3	0	0

Pre-requisites:
Knowledge of Microbiology, Unit Operations, Genetic Engineering, and Fermentation technology and Downstream Processing.

UNIT 1 **[06 hrs]**

DAIRY MICROBIOLOGY

Introduction and overview of dairy industry, Morphological and Biochemical Characteristics of important groups of Milk microbes and their Classification i.e. Psychrotrophs, Mesophiles, Thermodurics, and Thermophiles, Impact of various stages like Milking, Chilling, Storage and Transportation on microbial quality of Milk , Direct and Indirect Rapid techniques for assessment of microbial quality of milk, Food infection, Mastitis Milk: Organisms causing mastitis, Detection of somatic cell count (SCC), Role of Microorganisms in Spoilage of Milk; Souring, Curdling, Bitty Cream, Proteolysis, Lipolysis; Abnormal flavors and Discoloration.

UNIT 2 **[08 hrs]**

DAIRY BIOTECHNOLOGY

Genetic engineering of Bacteria and Animals intended for Dairy-based Products: DNA Cloning, Protoplast fusion & cell culture methods for trait improvement. Enzymes in Dairy industry & Production by whole cell immobilization. Biotechnology of Dairy Effluent treatment. Ethical issues relating to Genetic modification of Dairy microbes & Milk-yielding animals. By products technology: Physico-chemical characteristics of whey, butter milk and ghee residue; by-products from skim milk such as Casein; Whey processing & utilization of products generated from whey.

UNIT 3 **[15 hrs]**

DAIRY ENGINEERING

Homogenization: Single stage and Two stage Homogenizer pumps, Power requirements, Care and maintenance of homogenizers; Pasteurization: Batch, flash and continuous (HTST) pasteurizers, Flow diversion valve, Pasteurizer control, Care and maintenance of pasteurizers; Filling Operation: Principles and working of different types of bottle filters and capping machine, pouch filling machine (Pre-pack and aseptic filling bulk handling system, care and maintenance; Evaporation: Basic principles of evaporators, Different types of evaporators used in dairy industry, Calculation of heat transfer area and water requirement of condensers, Care and maintenance of evaporators; Drying: Introduction to principle of drying, Equilibrium moisture constant, bound and unbound moisture, Rate of drying- constant and falling rate, Effect of Shrinkage, Dryers-spray and drum dryers, spray drying, etc., air heating systems, Atomization and feeding systems; Fluidization: Mechanisms of fluidization characteristics of gas-fluidization systems, application of fluidization in drying. Membrane Processing: Ultra filtration, Reverse Osmosis and electro dialysis in dairy processing, membrane construction & maintenance for electro-dialysis & ultra-filtration, effect of milk constituents on operation.

UNIT 4 **[06 hrs]**

DAIRY PLANT DESIGN AND LAYOUT

Introduction of Dairy Plant design and layout, reception flexibility. Classification of dairy plants, selection of site for location. General points of considerations for designing dairy plant, floor plant types of layouts, service accommodation, single or multilevel design. Arrangement of different sections in dairy, Arrangement of equipment, milk piping, material handling in dairies. Drain layout for small and large dairies. Ventilation, fly control, mold prevention, illumination in dairy plants.

UNIT 5 **[04 hrs]**

QUALITY AND SAFETY MONITORING IN DAIRY INDUSTRY

Current awareness on quality and safety of dairy foods; consumer awareness and their demands for safe foods; role of Codex Alimentations Commission (CAC) in harmonization of international standards; quality (ISO 9001:2000) and food safety Hazard Analysis Critical Control Point (HACCP) system and their application during milk production and processing. National and international food regulatory standards; BIS, PFA, ICMSF, IDF etc., their role in the formulation of standards for controlling the quality and safety of dairy foods. Good Hygiene Practices (GHP).

Course Outcomes:

1. Apply the concept of starter cultures in dairy industries.
2. Understand the role of genetic engineering of microorganisms in dairy industry
3. Comprehend equipment operation for their use in dairy industry.
4. Understand Dairy plant design and layout
5. Describe the regulatory issues and good manufacturing practices related to dairy industries.

TEXT BOOKS

1. **Diary Science & Technology Handbook** by Ed by Hui, Y.H, Wiley Publishers, Vols 1-3.
2. **Diary Microbiology Handbook** by Robinson, R.K., Wiley Publishers, 3rd Edition.

REFERENCE BOOKS

1. **Comprehensive Biotechnology** by Ed N.C Gautam, Shree Pblns, Vol 6.
2. **General Microbiology** by Powar & Daginawala, Himalaya Publishers, Vol 2**.**
3. **Milk composition, production & biotechnology**: (Biotechnology in Agriculture Series 18)-CABI Publishers
4. **Handbook of Farm, Dairy & Food Machinery** by Myer Kutz, Andrew Publishers.

Course Title	MICROBIAL BT										Credits	3		
Course Code	1	1	B	T	7	D	E	M	B	T	L-T-P	3	0	0

Pre-requisites:
Knowledge of microbiology, molecular biology, genetic engineering, industrial biotechnology

UNIT 1 **[05 hrs]**

MICROBIAL DIVERSITY AND ITS APPLICATIONS

Characters of Eubacteria and Archeabacteria, principal mode of metabolism, Importance of identification, Taxonomic groups of important bacteria and fungi. Horizons of microbial technology-Human therapeutics, Agriculture, Wastewater treatment, Hazardous waste management, Feedstock chemicals (in brief)

UNIT 2 **[10 hrs]**

MACROMOLECULES FROM MICROBES

Brief introduction to genetic engineering in bacteria, Recovery and purification of expressed proteins. Production of proteins in yeast- Enhancement of foreign gene expression, expression in secreted form with example(insulin, factor VIII)

Recombinant and synthetic vaccines- important types, Microbial polysaccharides and polyesters- Bacterial polysaccharides, structural aspects, roles of microbial polysaccharides in nature. Xanthan Gum-Xanthomonas sp., structure, properties, biosynthesis, bulk production, modification of xanthan structure. Polyesters-occurrence of PHAs in nature, Biosynthesis and biodegradation of PHAs, Biosynthesis of copolyesters from single substrates, manipulation of growth conditions to produce novel bacterial polyesters, Use of cometabolism, GE of microbes.

UNIT 3 **[10 hrs]**

INDUSTRIAL MICROBIOLOGY

From Bio mass to Fuels- major components of plant biomass (brief introduction to general and structural properties), Microbial egradation of lignocellulose, role of enzymes. Ethanol production: StagI-from feedstocks to fermentable sugars, stageII-from sugars to alcohol(yeast and alternative producers). Simultaneous stage I and II process. Fuel ethanol-economic implications. Industrial production of amino acids: Fermentation with mutant strains and wild type strains, amino acid fermentation and RDT
(glutamate and asperagin as Ex.), aminoacid production with enzymes.Antibiotics: classes, and goals of antibiotic research, development of aminoglycosides, beta-lactums, physiology and genetics of antibiotic production.

UNIT 4 **[06 hrs]**

MICROBIAL ENZYMES

Microbial enzymes, strain, medium, fermentation processes. Large scale application of Microbial enzymes - starch processing, textile designing, detergents, diary industry, production of glucose isomerase.

UNIT 5 **[08 hrs]**

BIOREMEDIATION AND BIOLEACHING

Uses of Bacteria in Bioremediation – Biodegradation of hydrocarbons, Granular sludge consortia for bioremediation, crude oil degradation by bacteria, Immobilization of microbes for bioremediation, Methanotrophs, PCB dechlorination, Genetic engineering of microbes for bioremediation. Studies of Pyrite Dissolution in Pachuca Tanks and Depression of Pyrite Flotation by Bacteria, Factors affecting Microbial

Coal Solubilization, Sulfur Leaching by Thermophilic Microbes of Coal Particles Varying in size, Microbiological Production of Ferric Ion for Heap and Dump Leaching, New Bacteriophage which infects Acidophilic, Heterotrophic Bacteria from Acidic Mining Environments, Treatment of Coal Mine Drainage with Constructed Wetlands.

Course Outcomes:

1. Understand the characteristics of various microbes and their applications
2. Describe the production of macromolecules from microbes
3. Comprehend the industrial production of different metabolites from microorganisms
4. Identify the applications of various microbial enzymes
5. Describe the use of microorganisms in Bioremediation and bioleaching

TEXT BOOKS

1. **Microbial Biotechnology** by Alexander N Glazer, Hiroshi Nikaido, W H Freeman & Company New York, 4th edn.
2. **Fundamentals of Biotechnology** by Paule Prave, Uwe Faust, Wolfgang Sitting and Dieter A Sukatsch. VCH Publishers.
3. **Principles of fermentation Technology** by P.F. Stanbury and A. Whitaker, Pergamon Press, 1984.

REFERENCE BOOKS

1. **Microbiology** by Bernard Davis & Renato Dulbecco, Lippincott Company, Philadelphia.
2. **Principle of Microbe & Cell Cultivation** by SJ Prit, Blackwell Scientific co., 1975.

Course Title	BIOETHICS & BIOSAFETY										Credits	3		
Course Code	1	1	B	T	8	D	C	B	I	S	L-T-P	3	0	0

Pre-requisites:
Knowledge of Constitution of India and Professional Ethics, Microbiology, Genetic engineering, Pharamceutical BT, Animal BT, plant BT

UNIT 1 **[10 hrs]**

BIOTECHNOLOGY AND SOCIETY

Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. Public acceptance issues for biotechnology: Case studies/experiences from developing (Bt cotton and Bt brinjal) and developed countries. Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries. Ethical conflicts in biotechnology: - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics, Issue of technology transfers across the globe.

UNIT 2 **[06 hrs]**

BIOETHICS

The principles of bioethics: - autonomy, human rights, beneficence, privacy, justice, equity etc. Medical biotechnology and bioethics: - Probable controversial issues of Stem cell and gene therapy, Gene profiling, Access and exploration of human genome, synthetic or artificial cell. Ethical implications of biotechnological products and techniques.

UNIT 3 **[07 hrs]**

BIOSAFETY CONCEPTS AND ISSUES

Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. Biological weapons: - Types and possible role of RDT in production of novel bioweapons. Social, Economic and ethical implications of Bioterrorism. Biosafety levels: Different types and description. The Cartagena protocol on biosafety.

UNIT 4 **[10 hrs]**

BIOSAFETY & REGULATIONS IN R&D UNITS AND PRODUCTION FACILITIES

Laboratory associated infections and other hazards, assessment of biological hazards, prudent biosafety practices in the laboratory/ institution. Biosafety assessment procedures in India and abroad. International dimensions in biosafety: Catagena protocol on biosafety, bioterrorism and convention on biological weapons. Biosafety regulations and national and international guidelines with regard to rDNA technology, transgenic science, GM crops, etc. Experimental protocol approvals, levels of containment. Guidelines for research in transgenic plants. Good manufacturing practice and Good lab practices (GMP and GLP). Biosafety management: Key to the environmentally responsible use of biotechnology.

UNIT 5 **[06 hrs]**

ACCEPTANCE ISSUES IN FOOD, AGRICULTURE AND PHARMA SECTORS

The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Environmental aspects of biotech applications: - Use of genetically modified organisms and their release in environment (LMOs). Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Recombinant organisms and transgenic crops, case studies of relevance. Biosafety assessment of pharmaceutical products such as drugs/vaccines (products out of RDT), Bio-safety issues in clinical trails.

Course Outcomes:

1. Comprehend the importance of social responsibility in the relevant fields of biotechnology
2. Understand the positive and negative impacts of Biotechnology on the society.
3. Examine the ELSI associated with particular technology
4. Understand the safety issues and the governing regulations at national and international levels

TEXT BOOKS

1. **Biotechnology and Safety Assessment by Thomas** by J.A., Fuch, R.L. (2002), Academic Press.
2. **Bioethics & Biosafety** by R Rallapalli & Geetha Bali, APH Publication, 2007.

REFERENCE BOOKS

1. **Bioethics & Biosafety** by Sateesh MK (2008), IK Publishers.
2. **Biotechnologies in developing countries** by Sasson A, UNESCO Publishers, 1993.
3. **Biological safety Principles and practices** by Fleming, D.A., Hunt, D.L., (2000), ASM Press.
4. **Biotechnology - A comprehensive treatise. Legal economic and ethical dimensions** VCH.
5. **Biosafety Management** by P.L. Traynor, Virginia polytechnic Institute Publication, 2000.

Course Title	FORENSIC SCIENCE										Credits	3		
Course Code	1	1	B	T	8	D	E	F	R	S	L-T-P	3	0	0

Pre-requisites:
Knowledge of Human Physiology, Genetic Engineering, Immunotechnology

UNIT 1 **[06 hrs]**

INTRODUCTION

Introduction to Forensics, Definition and scopes of forensics, History and chronology of the events in forensics, (Contribution of various scientists and forensic experts in forensic sciences), and important milestones in the forensics, importance and significance of court in forensics (procedure and protocol:- Inquest and different types, medical examiners systems, powers of courts, different documentary evidences and witness, Doctors guide to court), application of the forensics in various fields.

UNIT 2 **[10 hrs]**

CRIME LAB & THE CRIME SCENE

Crime lab:

Organization of crime lab at various levels in India (Center and State), Basic services provided by full service crime laboratories (physical, biological unit, firearms unit, Document Examination unit, photograph unit, - functions and duties), optional services provided by full service crime laboratories (lie detector, toxicology, voice print analysis unit).

The Crime Scene:

Processing the crime scene (Crime scene, Preservation and record, methodic search for evidence, Collection and package of the evidences, maintain chain of custody, crime scene safety).

Physical evidences: common types & sources of physical evidences, Handling, packing and labeling of evidence, Individual and class characteristics, significance of physical evidences.

UNIT 3 **[10 hrs]**

FORENSIC ANALYSIS

Glass (nature of information obtained, properties, glass fractures, collection and preservation of glass evidence); Soil (forensic characteristics, collection and preservation); Hairs (Morphology, Identification and comparison, collection), Fibers (Types, Identification), semen, paint (collection, nature & examination), Blood (stain patterns, preservation, characterization).Selecting an analytical technique to identify a organic substance (Gas Chromatography, High Performance Liquid Chromatography, Thin Layer Chromatography, Electrophoresis)

UNIT 4 **[08 hrs]**

FORENSIC BIOLOGY

Forensic Pathology (Rigor mortis, Lovor mortis, Algor mortis); Forensic Anthropology, Forensic Entomology, Forensic Psychiatry, Forensic odontology, Forensic Engineering, DNA Analysis, Finger prints (Classification and patterns, ridge characteristics, Methods of detecting fingerprints).

UNIT 5 **[05 hrs]**

COMPUTER CRIME & ETHICS IN FORENSICS

Computer crime: Introduction and definition, classification (Physical, Data & software related), computer crime prevention measures, overview of cyber forensics.

Ethics in forensic science: Introduction, The importance of professional ethics to science practitioners, Various models of codes of ethics (broad model and Detailed model), How ethical requirement, impact the daily work of a forensic scientist, ethical dilemmas and their resolution.

Course Outcomes:

1. Comprehend on views of forensic procedure and protocols required to solve cases
2. Describe the organization of crime lab and processes sing of crime scene based on evidences
3. Summarize various types of evidences and methods of analyzing the evidences
4. Explain categories of cybercrime and ethics involved in Forensic sciences

TEXT BOOKS

1. **Criminalistics: An Introduction to Forensic Science** by Richard Saperstein, Prentice Hall, 2001.
2. **Forensic Science in Crime Investigation** by B.S.Nabar, Asia Law House, 3rd edition, 2007

REFERENCE BOOKS

1. **Principles of Forensic Medicine** by Apurba Nandy, New central book agency (p) Ltd.
2. **M.K.R.Krisnas's Handbook of Forensic Medicine including Toxicology** by V. P. Patnaik, Pras Medical Books, 11th edition, 1999.

Course Title	TISSUE ENGINEERING										Credits	3		
Course Code	1	1	B	T	8	D	E	T	S	E	L-T-P	3	0	0

Pre-requisites:
Knowledge of basic cell biology, Human physiology, Genetic Engineering, Animal Biotechnology, Chemistry, Basics of Biomolecules

UNIT 1 **[10 hrs]**

CELL AND TISSUE BIOLOGY

Introduction to human tissues and tissue development; Stem cells: Types (embryonic and adult).Morphology of human tissues (muscular tissue, adipose tissue, connective tissue, nervous tissue and epithelial tissues) and organs (heart, liver, kidney, pancreas, bone and bone marrow). Tissue homeostasis (slow, medium and highly regenerative tissues). Importance of cellular signaling and implementation of cell signaling principles in tissue engineering.

UNIT 2 **[06 hrs]**

CELL ADHESION AND ECM

Adhesion Receptors in Tissue Structures, Cell Adhesion to Biomaterials, Measurement of Cell Adhesion to Biomaterials, Effect of Biomaterial on Physiological Behavior. Introduction to cell migration, Characteristics of Mammalian Cell Migration, Regulation of Cell Movement, Cell Migration Assays, Mathematical Models for Cell Migration and Tissue Growth. ECM- composition and activities. Functional Integration of Implanted Materials, Basement Membranes and Focal Adhesions, Focal Adhesions as Signaling Complexes.

UNIT 3 [**11 hrs]**

BIOMATERIALS, SCAFFOLD DESIGN AND FABRICATION

a) Biological Scaffolds - Collagen, fibrinectin, Lamin, Glycosamino glycans: preparation, commercial availability and future prospects.

b) Natural Biopolymers-polysaccharides (alginate, dextran, chitosan, cellulose), proteins (collagen, elastin, fibroin)

c) Synthetic polymers - degradable polymers (pla, PGA, Pu and peo) and copolymers.
Polyhydroxy alkonate based polymers. Synthetic hydrogels. Calcium phosphate ceramics. Mechanical properties of biomaterials, Biocompatibility of biopolymers, Invitro assessment of biocompatibility/protein adsorption. Tissue biomechanics, scaffold design and fabrication. Drugs, growth factors and regulatory molecules delivery to the scaffolds. Polymer hydrogel delivery systems, Polymer microsphere technology.

UNIT 4 **[06 hrs]**

TISSUE ENGINEERING BIOREACTORS

Introduction to Invitro culture: Culture media (Preparation and sterilization), Harvesting, selection and expansion. Differentiation, Change of phenotype. Cryopreservation. Tissue, organ and organotypic cultures. Mass transport and nutrition gradients in tissue engineering (O_2) as model. Cryopreservation of organs and ECM- Freezing and vitrification. Most common Bioreactors in Tissue Engineering, Cell Seeding in Bioreactors, Bioreactor Applications in Functional Tissues, Design Considerations, Challenges in Bioreactor Technologies.

UNIT 5 **[6 hrs]**

CLINICAL IMPLEMENTATION AND REGULATIONS FOR ENGINEERED TISSUES

Tissue Engineering of Skin, Bone, tendon, Adipose Tissue Engineering Introduction, FDA Regulation, Regulation of Pharmaceutical / Medical Human Tissue Products in Europe/USA, Other considerations Relevant to Engineered Tissues.

Course Outcomes:

1. Understand the principle behind tissue development
2. Comprehend Cell adhesion and ECM
3. Identify, design and fabricate various scaffolds.
4. Describe bioreactor and design considerations in tissue engineering.
5. Apply the concepts of tissue engineering principles and approaches for development of artificial cells, tissue, organ replacement.

TEXT BOOKS

1. **Tissue Engineering** by Clemens Van Blitterswijk
2. **Tissue Engineering** by John P. Fisher, A G Mikos & Joseph D. Bronzino, CRC Press, 2007.

REFERENCE BOOKS

1. **Methods of Tissue Engineering** by Anthony Atala & P Lanza, Academic Press Elsevier 2006.
2. **Biocatalytic Membrane Reactor** by Drioli, Taylor & Francis, 2005
3. **Translational approaches in Tissue Engineering and regenerative medicine.**

Course Title	BIO MATERIALS										Credits	3		
Course Code	1	1	B	T	8	D	E	B	M	T	L-T-P	3	0	0

Pre-requisites:
Knowledge of basic cell and molecular biology, Human physiology, Chemistry, Basics of Biomolecules

UNIT 1 **[10 hrs]**
INTRODUCTION TO BIOMATERIALS
Introduction to Materials Science, bonding, atomic/molecular structure, Bond energies, resonance and the reactivity of organic functional groups needed for biomaterials Nucleophilic and Electrophilic groups, pKas of important biomolecules. Transition states, stability of six membered rings, intramolecular reactions. Hydrolysis reactions of biomaterials (esters, orthoesters, amides, ureathanes, acetal, schiff bases, hydrazones and carbonates), kinetics of hydrolysis reactions; Acid-base catalysis of hydrolysis reactions.

UNIT 2 **[06 hrs]**
BIOCOMPATIBILITY
Definition and classification of bio-materials, mechanical properties, visco elasticity, wound-healing process, body response to implants, Tissue and blood compatibility.

UNIT 3 **[10 hrs]**
IMPLANT MATERIALS
Metallic implant materials, stainless steels, co-based alloys, Ti-based alloys, ceramic implant materials, aluminum oxides, hydroxyapatite glass ceramics carbons, medical applications, Synthesis of polymeric biomaterials such as Polyesters, polyanhydrides, Polyorthoesters, Polyacetals, Polyamino-acids, Solid phase reactions of peptides and oligonucleotides, Dendrimers, PEG, Free radical polymerization, Bioconjugation reactions, maleimides and thiols, disulfide exchanges, Michael additions, amide formation, chemoselective ligations, polyolefin, polyamicles, Acryrilic, polymers, rubbers, high strength thermoplastics, medical applications.

UNIT 4 **[07hrs]**
TISSUE REPLACEMENT IMPLANTS
Soft-tissue replacements, sutures, surgical tapes, adhesive, percutaneous and skin implants, maxillofacial augmentation, blood interfacing implants, hard tissue replacement implants, internal fracture fixation devices, joint replacements.

UNIT 5 **[06 hrs]**
ARTIFICIAL ORGANS
Artificial Heart, Prosthetic Cardiac Valves, Limb prosthesis, Externally Powered limb Prosthesis, Dental Implants.

Course Outcomes:
1. Understand basic concepts of material science.
2. Describe the classification and properties of various biomaterials
3. Recognize the properties and applications of various implant materials
4. Comprehend the use of implants in tissue replacement
5. Understand the role of implants in artificial organs

TEXTBOOKS

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

REFERENCES

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

Course Title	PROTEIN AND INSILICO DRUG DESIGN										Credits	3		
Course Code	1	1	B	T	8	D	E	I	D	D	L-T-P	3	0	0

Pre-requisites:
Knowledge of Basics of Biomolecules, Biochemistry, Bioinformatics, Computational Biology and Pharmaceutical Biotechnology

UNIT 1 **[09 hrs]**

PROTEIN STRUCTURE PREDICTION AND ENGINEERING

Primary structure and its determination, secondary structure prediction and determination of motifs, profiles, patterns, fingerprints, super secondary structures, protein folding pathways, tertiary structure, quaternary structure, methods to determine tertiary and quaternary structure, post translational modification. Methods of protein isolation, purification and quantification; large scale synthesis of engineered proteins, design and synthesis of peptides; methods of detection and analysis of proteins. Protein database analysis, methods to alter primary structure of proteins, examples of engineered proteins

UNIT 2 **[07 hrs]**

MOLECULAR MODELING

Constructing an Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure Generation or Retrieval, Structure Visualization, Conformation Generation, Deriving Bioactive Conformations, Molecule Superposition and Alignment, Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Molecular Interactions: Docking, Calculation of Molecular Properties

UNIT 3 **[07 hrs]**

INSILICO DRUG DESIGN

Generation of Rational Approaches in Drug Design, Molecular Modeling: The Second Generation, Conceptual Frame and Methodology of Molecular Modeling, The Field Currently Covered, Importance of the "Bioactive Conformation", Molecular Mimicry and Structural Similarities, and Superimposition Techniques, Rational Drug Design and Chemical Intuition, An Important Key and the Role of the Molecular Model, Limitations of Chemical Intuition

UNIT 4 **[07 hrs]**

DOCKING METHODS

Three - Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Method, Three-Dimensional Database Search Approaches, Automated Structure Construction Methods, Structure Construction Methods with known Three-Dimensional Structure of the Receptor, Structure Construction in the case of Unknown Receptor Structure. Points for Consideration in Structure Construction Methods, Handling of X-Ray Structures of Proteins, Future Perspectives. Other web based programs available for molecular modeling, molecular docking and energy minimization techniques – Scope and limitations, interpretation of results.

UNIT 5 **[09 hrs]**

COMPUTER ASSISTED NEW LEAD DESIGN AND DRUG DISCOVERY

Introduction, Basic Concepts, Molecular Recognition by Receptor and Ligand Design, Active Conformation, Approaches to Discover New Functions, Approaches to the Cases with known and unknown receptor structure, The Drug Development Process, Introduction, The Discovery and Development Process, New Lead Discovery Strategies, Composition of Drug Discovery Teams, The Practice of Computer-Assisted Drug Discovery (CADD), Current Practice of CADD in the pharmaceutical Industry, Management Structures of CADD Groups, Contributions and Achievements of CADD Groups, Limitations of CADD Support, Inherent Limitations of CADD Support, State of Current Computational Models, Software and Hardware Constraints.

Course Outcomes:

1. Understand protein structure and engineering.
2. Comprehend the construction and structure generation by molecular modeling
3. Design drugs through molecular modeling
4. Describe various docking methods
5. Explain the computer assisted and new Lead drug discovery strategies

TEXT BOOKS

1. **The molecular modeling perspective in drug design** by N Claude Cohen, 1996, Academic Press.
2. **Protein Engineering** by Moody P.C.E. and A.J. Wilkinson, IRL Press, Oxford, 1990.
3. **Biochemistry** by Voet and Voet, Wiley New York.

REFERENCE BOOKS

1. **Bioinformatics Methods & Applications-Genomics, Proteomics & Drug Discovery** by S C Rastogi, N Mendiratta & P Rastogi, PHI, 2006.
2. **Fundamentals of Biochemistry** by John Willey, 3rd edition, 2004.

Course Title	NANO BIOTECHNOLOGY										Credits	3		
Course Code	1	1	B	T	8	D	E	N	B	T	L-T-P	3	0	0

Pre-requisites:
Knowledge of basic biology, Mathematics, Chemistry, Cell and molecular biology, Process Engineering Thermodynamics, Bioanalytical techniques, Biosensors and Bioinstrumentation, Computational Biology, Pharmaceutical Biotechnology and Microarray technology

UNIT 1 **[08 hrs]**

INTRODUCTION

A Brief History, requisite definitions, Nano fabrication: Bottom-Up (gaseous phase method, Liquid phase method and solid phase bottom up fabrication), Top-Down (Mechanical, thermal, High energy and chemical methods), nanolithography, Microelectronic fabrication. Structure- property relationships in materials. Biomolecule-surface interactions. Fabrication on Hard Materials: Silicon and glass materials for nano- and micro fabrication, Fabrication in Soft Materials: Hydrogels/PDMS/other polymers and base materials for nano- and micro fabricated devices.

UNIT 2 **[10 hrs]**

NANOSTRUCURES

Buckyballs, Nanotubes, Fullerenes, Carriers, Dendrimers, Nanoparticles, Membranes / Matrices, Nano shells, Quantum Dot, Nano crystals, hybrid biological/inorganic devices, tools for nano structuring and for characterization of nanostructures: Scanning tunneling microscopy, Atomic force microscopy, X-ray spectroscopy, Surface enhanced Raman spectroscopy, Lithography. Biocompatibility of nanostructures. Interaction of nanoparticles with cells. Assessment of the toxic effects.

UNIT 3 **[10 hrs]**

NANODIAGNOSTICS & NANO MEDICINE

Function and application of DNA based nanostructures- DNA microarrays, Nanofabricated devices to separate and interrogate DNA. Nano biosensors. . Interrogation of immune and neuronal cell activities through micro- and nanotechnology based tools and devices. Nano therapeutics: Drug Discovery Using Nano crystals, Resonance Light Scattering (RLS) and Nano sensors. Benefits of Nano-Imaging Agents, Drug Delivery. Drug Delivery Applications- Bioavailability, Sustained and targeted release, Benefits of Nano-Drug Delivery. Nano robots. Health risks and challenges.

UNIT 4 **[05 hrs]**

MICROFLUIDICS

Laminar flow, Hagen-Pouiselle eqn, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps, Approaches toward combining living cells, microfluidics and 'the body' on a chip, Chemotaxis, cell motility. Case Studies in Microfluidic Devices.

UNIT 5 **[06 hrs]**

BIOMEMS

Introduction and Overview, Biosignal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers – Sensing and actuating mechanisms.

Course Outcomes:

1. Understand the concepts in Nano fabrication
2. Describe the tools for Nano structuring and characterization of Nano structures
3. Identify the applications of Nano biosensors in Diagnostics and therapeutics
4. Comprehend the importance of flow properties in Nanotechnology
5. Describe the mechanism in various transducers.

TEXT BOOKS

1. **Biological molecules in Nanotechnology** by Stephen Lee and Lynn M Savage
2. **Nanobiotechnology Protocols** by Rosenthal, Sandra J and Wright, David W., Humana Press,
3. 2005.
4. **Nanotechnology** by Richard Booker and Earl Boysen (Eds), Wiley dreamtech 2005 edition
5. **Nanotechnology – Basic Science & Emerging Technologies** by Chapman & Hall/CRC 2002.
6. **Nanotechnology** by Gregory Timp (Ed), Spring 1998.

REFERENCE BOOKS

1. **Unbounding the future** by K Eric Drexler
2. **Nanotechnology – A gentle Introduction to the Next Big Idea** by Mark Ratner and Daniel
3. Ratner, Pearson Education, 2005.
4. **Transducers and instrumentation** by D.V.S. Murthy, Prentice Hall of India.
5. **Principles of Applied Biomedical Instrumentation** by Geddes (L.A.) & Baker (L.E), Edn. 3.
6. **Biochip Technology** by Jing Chung & Larry J. Kricka Harwood academic publishers, 2001.

Course Title	FACILITATION, VALIDATION & QC										Credits	3		
Course Code	1	1	B	T	8	D	E	F	V	Q	L-T-P	3	0	0

Pre-requisites:
Knowledge of Pharmaceutical Biotechnology , Management and Entrepreneurship, Research Methodology and Process Plant Design and Economics

UNIT 1 **[07 hrs]**

INTRODUCTION

Validation and Regulatory Affairs in Bio (Pharmaceutical) Manufacturing: An Introduction to FDA Operations & Industry Compliance Regulations, The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP), Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP). An Introduction to the Basic Concepts of Process Validation & how it Differs from Qualification (IQ, OQ & PQ) Procedures, A Review of Prospective, Concurrent, Retrospective Validation & Revalidation including the use of Statistical Process Control (SPC) Techniques.

UNIT 2 **[10 hrs]**

PLANNING & VALIDATION

ISO 9000 Series & International Harmonization & their effect upon GMP's, Planning & Managing a Validation Program including Change Control, Scale-Up and Post-Approval Changes (SUPAC), PAI & Technology Transfer Issues. Validation of Water & Thermal Systems, including HVAC Facilities & Cleaning Validation. Validation of Active Pharmaceutical Ingredients (APIs) & Aseptic Processes. Validation of Non-Sterile Processes (used in the manufacture of Solids, Liquids, & Semisolid Dosage Forms).

Overview of methods of evolution, FDA and ICH guidelines, Development and validation, Basic statistical concepts, Specificity: sample preparation, separations,: detectors, Linearity, Accuracy, Precision, Limits of detection (LOD) and quantification (LOQ), Minimum detectable amount (MDA), Sample stability and method robustness, Window diagrams, System suitability, Statistical process control for HPLC, Sustainable validation, Troubleshooting out-of-control systems.

UNIT 3 **[08 hrs]**

GAMP AND STANDARDS

Medical Devices, In-Vitro Diagnostics & Packaging :Validation Issues, Validation of Analytical Methods, Computerized & Automated Systems under 21 CFR Part 11 & the Influence of Good Automated Manufacturing Practice (GAMP); The FDA's Approach to GMP Inspections of Pharmaceutical Companies. ISO 9000 Series of Standards, Management Responsibility, Quality System, Contract Review, Design Control, Document and Data Control, Preservation and Delivery, Control of Quality Records, Internal Quality Audits, Training, Servicing, Statistical Techniques, ISO-9001-2000, Scope, Normative Reference, Terms and Definitions, Quality Management, System, Documents Requirements, Management's Responsibility, Resource Management, Infrastructure, Product Realization, Measurement, Analysis and Improvement, ISO-14001 - Environmental Management Systems.

UNIT 4 **[05 hrs]**

IMPLEMENATION

Quality System, Contract Review, Design Control, Document and Data Control, Purchasing, Control of Customer Supplied Product, Product Identification and Traceability, Process Control, Inspection and Testing, Final Inspection and Testing, Control of Inspection, Measuring and Test Equipment, Inspection and Test Status, Control of Nonconforming Product, Corrective and Preventive Action, Handling, Storage, Packaging, Preservation and Delivery, Control of Quality Records, Internal Quality Audits, Training, Servicing, Statistical Techniques.

UNIT 5 **[09 hrs]**

QUALITY CONTROL AND MANAGEMENT

Objectives of QC, Customer Satisfaction, Capability; Terms Relating to Management, Management System, Quality Management System, Quality Policy, Quality Planning, Quality Control, Quality Assurance, Quality Improvement, Continual Improvement, Effectiveness, Efficiency; Relating to Process and Product, Process, Product, Procedure; Terms relating to Characteristics, Quality Characteristics; Terms Relating to Conformity, Non-Conformity, Defect, Preventive Action, Corrective Action, Correction, Rework, Repair, Scrap, Concession, Deviation Permit, Release; Terms Relating to Documentation, Information, Document, Specification, Quality Manual, Quality Plan, Record; Terms Relating of Examination, Objective Evidence, Inspection, Test, Metrological Confirmation. The development of regulatory requirements for validation, The V model and Life Cycle model approach to validation and documentation, Risk Analysis Techniques: Impact Assessment; Failure Mode and Effects Analysis (FMEA), Validation Master Plans, Commissioning and Qualification, Process Validation, Routine validation and revalidation, Contamination Control, Risk Management in the Pharmaceutical Industry, Solid Dose Manufacture Principles and Practices, Liquid and Cream Manufacture Principles and Practices, Good Laboratory Practices (for Non-Clinical Laboratories), Computer Systems Validation Principles and Practices, Good Aseptic Practices and Sterile Products, Clinical Trials Quality Assurance Management, GxP and Quality Auditing Practices, Pharmaceutical Engineering – Facility, Equipment and Process Design, Fundamentals of Process Analytical Technology, Quality and Continuous Improvement in the Pharmaceutical Industry.

Course Outcomes:

1. Comprehend the regulatory affairs in Pharmaceutical Manufacturing
2. Describe the validation of active Pharmaceutical ingredients and aseptic processes
3. Understand the importance of GAMP and ISO standards in Pharmaceutical manufacturing
4. Explain the implementation of control measures taken in process and product development
5. Identify the objectives of Quality control and management

TEXT/REFERENCE BOOKS

1. **Pharmaceutical Process Validation** edited by Robert Nash and Alfred Wachter, Marcel Dekker, 3rd Edition, 2003.
2. **Good Manufacturing Practices for Pharmaceuticals-A Plan for Total Quality Control From Manufacturer to Consumer** by Sidney J. Willig, Marcel Dekker, 5th Ed., 2000, 723 pp.,
3. **Validation of Pharmaceutical Processes** by Sterile Products, Frederick J. Carlton (Ed.) and James Agalloco (Ed.), Marcel Dekker, 2nd Ed., 1998.

4. **Validation Standard Operating Procedures: A Step by Step Guide for Achieving Compliance in the Pharmaceutical, Medical Device, and Biotech Industries** by Syed Imtiaz Haider, Saint Lucie Press, 2002, 496.
5. **Pharmaceutical Equipment Validation-The Ultimate Qualification Handbook** by Phillip A. Cloud, Interpharm Press, 1998.
6. **Commissioning and Qualification**: ISPE Pharmaceutical Engineering Baseline Guides Series, 2001.