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: 2015-18)

BMS COLLEGE OF ENGINEERING, BANGELORE
(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	S	Credit Total		CIE	SEE	Total
1	5	B	T	3	D	C	B	B	M	Basics of Biomolecules	2	1	0	0	3	4	50	50	100
1	5	B	T	3	D	C	C	M	B	Cell & Molecular Biology	3	0	1	2	6	5	50	50	100
1	5	B	T	3	D	C	M	B	G	Microbiology	2	0	1	2	5	4	50	50	100
1	5	B	T	3	D	C	P	E	T	Process Engg Thermodynamics	3	1	0	0	4	5	50	50	100
1	5	B	T	3	D	C	U	O	1	Unit operations-1	2	1	0	0	3	4	50	50	100
1	5	M	A	3	G	C	A	P	M	Applied Mathematics	3	1	0	0	4	5	50	50	100
Total															**25**	**27**	**300**	**300**	**600**

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week; **P-**Practical Lecture Hours/week; **S-**Self study

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	S	Total		CIE	SEE	Total
1	5	B	T	4	D	C	B	A	B	Biochemistry & Bioenergetics	2	1	1	0	4	6	50	50	100
1	5	B	T	4	D	C	U	O	2	Unit Operations-2	3	0	1	2	6	5	50	50	100
1	5	M	A	4	D	C	B	S	P	Engg Maths-IV (Biostatistics and probability)	3	1	0	0	4	5	50	50	100
1	5	B	T	4	D	C	E	B	T	Environmental Biotechnology	3	0	0	0	3	3	50	50	100
1	5	B	T	4	D	C	B	C	A	Basics of Computer applications	2	0	1	2	5	4	50	50	100
1	5	B	T	4	D	C	P	P	C	Process principles and calculations	2	1	0	0	3	4	50	50	100
Total															**25**	**27**	**300**	**300**	**600**

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week; **P**-Practical Lecture Hours/week, **S**-Self Study.

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	Marks		
		L	T	P	S	Total		CIE	SEE	Total
16BTDCBAT	Bioanalytical Techniques	3	1	0	0	4	5	50	50	100
16BTDCBIN	Bioinformatics	3	0	1	2	6	5	50	50	100
16BTDCREN	Reaction Engineering	2	1	0	0	3	4	50	50	100
16BTDCGEN	Genetic Engineering	3	0	1	2	6	5	50	50	100
16BTDCIMM	Immunotechnology	3	0	0	0	3	3	50	50	100
16BTDEEL A	Elective-A	3	0	0	0	3	3	50	50	100
Total		**17**	**2**	**2**	**4**	**25**	**25**	**300**	**300**	**600**

Elective A															
Course Code										Course Title	Credit Hours/Week					Contact Hrs/wk	Marks		
											L	T	P	S	Total		CIE	SEE	Total
16BTDEABT										Animal Biotechnology	3	0	0	0	3	3	50	50	100
16BTDEMBT										Microbial Biotechnology	3	0	0	0	3	3	50	50	100
16BTDEHPH										Human Physiology	3	0	0	0	3	3	50	50	100
16BTDEPBT										Plant Biotechnology	3	0	0	0	3	3	50	50	100

L-Lecture Hours/week, **T**-Tutorial Lecture Hours/week, **P**-Practical Lecture hours/week, **S**-self study

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	Credits/ hours per wk					Contact Hrs/ wk	Marks		
											L	T	P	S	Total		CIE	SEE	Total
1	6	B	T	6	D	C	B	P	T	Bioprocess Technology	3	0	1	2	6	5	50	50	100
1	6	B	T	6	D	C	E	T	K	Enzyme Technology & Kinetics	2	1	1	2	6	6	50	50	100
1	6	B	T	6	D	C	G	A	P	Genomics & Proteomics	3	0	0	0	3	3	50	50	100
1	6	B	T	6	D	C	P	B	T	Pharmaceutical Biotechnology	3	0	0	0	3	3	50	50	100
1	6	B	T	6	D	C	P	C	A	Process Control and Automation	2	1	1	0	4	6	50	50	100
1	6	B	T	6	D	E	E	L	B	Elective-B	3	0	0	0	3	3	50	50	100
Total											**16**	**2**	**3**	**4**	**25**	**26**	**300**	**300**	**600**

Elective B																			
Course Code										Course Title	Credit Hours/Week					Contact Hrs/wk	Marks		
											L	T	P	S	Total		CIE	SEE	Total
1	6	B	T	6	D	E	M	T	E	Metabolic Engineering	3	0	0	0	3	3	50	50	100
1	6	B	T	6	D	E	B	I	B	Bioinstrumentation & Biosensors	3	0	0	0	3	3	50	50	100
1	6	B	T	6	D	E	G	I	N	Genome Informatics	3	0	0	0	3	3	50	50	100
1	6	B	T	6	D	E	F	B	T	Food Biotechnology	3	0	0	0	3	3	50	50	100

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week, **P**-Practical Lecture Hours/week, **S**- Self Study.

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/wk	Marks		
		L	T	P	S	Total		CIE	SEE	Total
16BT7OIEL1	Institutional Elective-I	3	0	0	0	3	3	50	50	100
16BT7DCEQD	Bioprocess Equipment Design and CAED	2	1	1	0	4	6	50	50	100
16BT7DCPPE	Process Plant design & Economics	2	1	0	0	3	4	50	50	100
16BT7DCBIP	Bioethics, Biosafety and IPR	3	0	0	2	5	3	50	50	100
16BT7DCMPR	Mini project	0	0	4	0	4	4	50	50	100
16BT7DEELC	Elective-C	3	0	0	0	3	3	50	50	100
16BT7DCBFS	Biotechnology for society	1	0	0	2	3	1	50	50	100
Total		**14**	**2**	**5**	**4**	**25**	**24**	**350**	**350**	**700**

Elective C															
Course Code	Course Title	Credit Hours/Week					Contact Hrs/wk	Marks		
		L	T	P	S	Total		CIE	SEE	Total
16BT7DEIBT	Industrial Biotechnology	3	0	0	0	3	3	50	50	100
16BT7DEAMT	Aqua & Marine BT	3	0	0	0	3	3	50	50	100
16BT7DEBTE	Biomaterials & Tissue Engineering	3	0	0	0	3	3	50	50	100
16BT7DECDM	Clinical Data Management	3	0	0	0	3	3	50	50	100

L-Lecture Hours/week, **T**-Tutorial Lecture Hours/week, **P**-Practical Lecture hours/week, **S**-self study

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	Credits/ hours per wk					Contact Hrs/ wk	Marks		
		L	T	P	S	Total		CIE	SEE	Total
16BT8OIEL2	Institutional Elective-II	3	0	0	0	3	3	50	50	100
16BT8DCPMF	Project management and Finance (HSS Core)	3	0	0	0	3	3	50	50	100
16BT8DEELD	Elective D	3	0	0	0	3	3	50	50	100
16BT8DCPRW	Project work	0	0	11	0	11	11	50	50	100
16HS8DCMME	Management & Entrepreneurship	3	0	0	0	3	3	50	50	100
16BT8DCIRS	Internship/Industrial Training/ technical seminar	0	0	2	0	2	2	50	50	100
Total		**12**	**0**	**13**	**0**	**25**	**25**	**300**	**300**	**600**

*CIE & SEE needs to be decided

Elective D

Course Code	Course Title	Credit Hours/Week					Contact Hrs/wk	Marks		
		L	T	P	S	Total		CIE	SEE	Total
16BT8DETRP	Transport Phenomena	3	0	0	0	3	3	50	50	100
16BT8DENBT	Nano-Biotechnology	3	0	0	0	3	3	50	50	100
16BT8DEDAN	Data Analytics	3	0	0	0	3	3	50	50	100
16BT8DEAPG	Advanced Programming	3	0	0	0	3	3	50	50	100

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week, **P**-Practical Lecture Hours/week, **S**- Self Study.

CIE-Continuous Internal Evaluation; **SEE**-Sem

COURSE TITLE	BASICS OF BIOMOLECULES										Credits	3			
COURSE CODE	1	5	B	T	3	D	C	B	B	M	L-T-P-S	2	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

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

COURSE DESCRIPTION: This course describes the structures of important biological molecules along with the basic concepts of organic and solution chemistry.

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

UNIT - 1

BASIC CONCEPTS [6L+3T]

Types of reaction mechanisms, 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.

UNIT - 2

STRUCTURE OF CARBOHYDRATES [5L+3T]

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

UNIT - 3

STRUCTURE OF LIPIDS [3L+2T]

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

UNIT - 4

STRUCTURE OF AMINO ACIDS AND PROTEINS [7L+3T]

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 Hemoglobin as an example.

UNIT - 5

STRUCTURE OF NUCLEIC ACIDS [5L+2T]

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

Bibliography

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Principles of Biochemistry by Lubert Stryer Freeman (Int. Ed.)
2. Principles of Nucleic Acid Structure by Sanger, Springer Verlag
3. Principles of Protein Structure by G Schulz and R H Schrimer, Springer Verlag

e-books:

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

MOOCs:

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

COURSE OUTCOMES (COs):

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

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

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

COURSE TITLE	CELL AND MOLECULAR BIOLOGY										Credits	6			
COURSE CODE	1	5	B	T	3	D	C	C	M	B	L-T-P-S	3	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of Basic biology.

COURSE DESCRIPTION: The Cell biology component of the course is designed to impart knowledge on the structural and functional details of the cell. It deals with chemical nature, structural organization, and function of various organelles of different types of the cells and the nature of genetic material & inheritance patterns of living organism. The Molecular biology component of the course focuses on the molecular aspects of the cell and its molecular components especially DNA, RNA and protein. It deals with all cellular processes involving the genetic material and its output, viz., replication, transcription, translation, DNA repair and Recombination as well as their regulation.

COURSE OBJECTIVES: The objective of the course is to make graduates understand the concepts of cell and molecular process and provide a background appropriate for applying the knowledge in applied biotechnology such as genetic engineering, genomics, Bioinformatics, Pharmaceutical Biotechnology, diagnostics, and therapeutics.

PART A : THEORY

UNIT - 1

THE CELL [10 HOURS]

i) Membrane systems, Organelle and their functions: Cell membrane, Nucleus, chromosomes and their packing, Mitochondria, chloroplast, peroxisomes, lysosome, vacuole, Golgi bodies, Endoplasmic reticulum, ribosomes

ii) Cytoskeletal elements and cellular transport: Microfilaments, intermediate filaments, microtubules, Cytoskeletal dynamics, extracellular and intracellular transport

iii) Cell division and its regulation: cell cycle, mitosis, meiosis and their regulation.

iv) Cell signaling: information flow at systems-level, cell signaling pathways and networks.

UNIT - 2

GENES AND INHERITANCE [06 HOURS]

i) Genes and genomes : PK and EK genes , genomes and their organization

ii) Inheritance: Mendelian and Non-Mendelian inheritance, Multiple alleles, Sex determination, linkage and crossing over, chromosomal disorders, Bacterial conjugation.

UNIT - 3

MOLECULAR MECHANISMS OF CELL-I [07 HOURS]

i) Replication: Proof of concept, PK and EK DNA replication and their models

ii) Transcription: PK and EK transcription, post transcriptional modifications, inhibitors of transcription

UNIT – 4

MOLECULAR MECHANISMS OF CELL-II [10 HOURS]

i) Translation: Concepts of genetic code, PK and EK translation, post translational modifications, inhibitors of Translation.

ii) Cell sorting ,translocation and transport

iii) Regulation of transcription and translation: Control at global and gene level, Operons and Positive verses negative regulation.

UNIT – 5

REGULATION AND REPAIR [06 HOURS]

Mutations, Recombination & repair: DNA damage, classification of mutations, mutagens, DNA repair, transposons, Recombination.

PART B: CELL & MOLECULAR BIOLOGY LAB (2 hrs/week)

1. Study of mitosis from onion root tips
2. Study of meiosis from onion flower buds.
3. Chloroplast isolation.
4. Isolation and fusion of protoplast.
5. Differential staining of blood cells.
6. Isolation of genomic DNA from bacteria/ plant/ animal cells.
7. Isolation of plasmid DNA .

8. Agarose gel electrophoresis for size determination.
9. Polytene chromosome from Drosophila.
10. Pedigree analysis.

REFERENCES

TEXT BOOKS:

1. Molecular Biology of the Cell, Bruce Alberts Garland Science Pub.
2. Genetics by Monroe W Strickberger Macmillan pub.
3. Cell and Molecular Biology by Gerald Karp, John Wiley & Sons.
4. Genes VIII/IX/X by Lewin

REFERENCE BOOKS:

1. Cell and Molecular Biology by Lodish, Freeman pub.
2. Cell Biology by J W Kimball, Addison-Welsey Pub.
3. Molecular Cell Biology by Darnell and Baltimore.

e- books:

1. Molecular Biology of the Cell, Bruce Alberts Garland Science Pub.
   http://bit.ly/MolBioCell5thPDFFree
2. Molecular Biology by David Freifelder
   https://openlibrary.org/authors/OL773152A/David_Freifelder

MOOCs:

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

COURSE OUTCOMES (COs):

CO 1	Describe structure and function of cell and organelles.
CO 2	Understand the concepts of inheritance and apply to solve related problems.
CO 3	Explain mechanism of DNA replication, transcription and translation.
CO 4	Comprehend mechanisms of gene regulation as well as DNA damage, repair and recombination processes**.**

CO 5	Demonstrate ability to conduct experiment, interpret and analyze data related to cell and its processes.
CO 6	Identify problems related to cell and its molecular processes, formulate solution and derive valid conclusions

ASSESSMENT:

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

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

COURSE TITLE	MICROBIOLOGY										Credits	5			
COURSE CODE	1	5	B	T	3	D	C	M	B	G	L-T-P-S	2	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

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

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

COURSE OBJECTIVES: To enable the students to

- understand the working principle of various types of microscopes
- Select an appropriate microscopic technique for identification of microorganisms.
- Gain knowledge in biology of microbial organisms, microbial metabolic pathways, and their industrial applications.
- develop ability to isolate and characterize and produce a desired a product from microorganism
- Develop ability to control microbes in engineering practices.

PART A : THEORY

UNIT - 1

INTRODUCTION [5 HOURS]

History of Microbiology, The Scope of Microbiology, 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

MICROBIAL NUTRITION AND GROWTH [6 HOURS]

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.

UNIT - 3

STUDY OF MICROORGANISMS [5 HOURS]

Genetic recombination in bacteria, reproduction & morphology and classification of fungi. Viruses of Bacteria: general characteristics, morphology and structure, the classification and nomenclature of bacteriophages, replication of bacterial viruses, Lysogeny.

Microbial Metabolism-overview of Metabolic pathways (Glycolysis, HMP, ED pathway, alcohol and acid fermentation-homo & heterolactic, mixed acid), Primary and secondary Metabolites-brief mention with examples and applications**.**

UNIT - 4

CONTROL OF MICROORGANISMS [5 HOURS]

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

UNIT - 5

APPLIED MICROBIOLOGY [5 HOURS]

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

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.

Bibliography

TEXT BOOKS:

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

REFERENCE BOOKS:

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

e- books:

1. http://www.austincc.edu/rohde/noteref.htm

2. http://www.freebookcentre.net/medical_books_download/Medical-Microbiology.html

3. http://books.pakchem.net/microbiology-books.html

MOOCs:

1. https://www.mooc-list.com

2. https://www.mysliderule.com/topic/microbiology

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

COURSE OUTCOMES (COs):

CO 1	**a)** Ability to describe principle of various types of microscopes and demonstrate

	their effective use **b)** Ability to Select an appropriate microscopic technique for identification microbes.
CO 2	**a)** Understand the structure and biology of microbial organisms. **b)** Describe the various metabolic pathways and industrial applications of microbial organisms **c)** Ability to measure microbial growth using suitable technique.
CO 3	Conduct experiments, and draw inferences for isolation, characterization and produce a desired a product using microorganism.
CO 4	Conduct sterilization techniques for control measures in Biotechnological engineering practices

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

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

COURSE TITLE	PROCESS ENGINEERING THERMODYNAMICS										Credits	4			
COURSE CODE	1	5	B	T	3	D	C	P	E	T	L-T-P-S	3	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

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

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

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

UNIT - 1

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

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

UNIT - 2

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

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

UNIT – 3

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

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

UNIT - 4

PHASE EQUILIBRIA [7L+3T]

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

UNIT - 5

BIOCHEMICAL ENERGETICS [8L+2T]

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

Bibliography

TEXT BOOKS:

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

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

REFERENCE BOOKS:

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

e-books:

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

MOOCs:

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

COURSE OUTCOMES (COs):

CO 1	Identify the various types of systems, processes and to solve engineering problems using laws of thermodynamics.
CO 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.
CO 3	Solve problems related to properties of pure fluids and solutions.
CO 4	Apply the concept of phase equilibria, reaction equilibria and energetics in the Biochemical engineering problems.

ASSESSMENT:

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

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

COURSE TITLE	UNIT OPERATIONS-1										Credits	3			
COURSE CODE	1	5	B	T	3	D	C	U	O	1	L-T-P-S	2	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of Engineering Physics and Mathematics

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

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

UNIT - 1

DIMENSIONAL ANALYSIS [2L+1T]

Units and Dimensions: Fundamental and derived units, Conversion. Dimensionless groups and constants. Dimensional analysis: Rayleigh's method, Buckingham's π method.

UNIT - 2

FLUID FLOW PHENOMENA [5L+2T]

Fluid definition and Classification (Newtonian and Non-Newtonian), Newton's law of viscosity, Pressure measurement using manometers, Hydrostatic equilibrium, Types of flow-laminar & turbulent, Flow in Boundary Layers, Reynolds experiment.

UNIT - 3

FLOW OF INCOMPRESSIBLE FLUIDS [6L+3T]

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

UNIT - 4

FLOW MEASUREMENTS [4L+4T]

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

UNIT- 5

MECHANICAL OPERATIONS [9L+3T]

Size reduction – Laws governing size reduction and equipment, Sieve analysis – Types, Screen effectiveness & capacity, Sedimentation & Settling - Batch & Continuous Sedimentation, Stoke's law, Terminal settling velocity. Kynch theory and Thickener design. Mixing – Types of mixers, power number, power consumption in mixing operation, Filtration - constant rate and constant pressure filtration, Filtration equipments, Cyclone separators and classifiers. Fluidization -Characteristics of fluidized systems, flow through packed beds, Conveyors - Slurry transport, Pneumatic conveyors, Mechanical conveyors, and elevators (Screw conveyor, Belt conveyor, Bucket elevator, continuous flow conveyor elevators), storage of solids.

Bibliography

TEXT BOOKS:

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

REFERENCE BOOKS:

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

e-books:

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

MOOCs:

1.https://www.edx.org/course/basics-transport-phenomena-delftx-tp101x#!

2.http://www.nptel.ac.in/syllabus/102106027/

COURSE OUTCOMES (COs):

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

ASSESSMENT:

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

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

Course Title	Applied Mathematics	Course Code	15MA3GCAPM
Credits	04	L – T – P- S	3 – 1 – 0 - 0
Contact hours	48 hours (36L+12T)		

COURSE PREREQUISITES: Concepts of Trigonometry, Trigonometric formulas. Concepts of: differentiation, partial differentiation and integration. Solution to ordinary differential equations.

COURSE OBJECTIVES: The purpose of the course is to make the students well conversant with Fourier- Series, Fourier Transforms, formulate physical problems in terms of Partial Differential Equations, find insight into the physical behaviour of systems from mathematical solution and develop computational skills using efficient numerical methods for problems in science and engineering.

COURSE DESCRIPTION: The course is an introduction to matrices, Fourier series and Fourier Transforms techniques. Modelling of physical problems involving the heat and wave equation and solve the partial differential equations using analytical techniques such as the method of separation of variables and Fourier transform. The course also offers an exposure to an optimisation technique involving functionals. Emphasis being given to solve engineering oriented problems.

UNIT-1

MATRICES **[9 hours]**

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

Suggested Reading: Inverse of a matrix by Gauss-Jordan method. Largest eigenvalue and corresponding eigenvector using Rayleigh power method.

UNIT-2

NUMERICAL METHODS **[10 hours]**

Solution of algebraic and transcendental equations: Newton-Raphson method. Finite Differences and interpolation: Forward differences, backward differences. Newton-Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical integration: Simpson's 1/3rd ,

3/8th rule, Weddle's rule. Numerical solution of ordinary differential equations: Runge-Kutta method of fourth order. **(8L+2T)**

Suggested Reading: Euler's modified method and Milne's method to solve ordinary differential equations. Solution of simultaneous differential equations by Runge-Kutta method of fourth order.

UNIT-3

FOURIER SERIES AND FOURIER TRANSFORMS [13 hours]

Introduction: Periodic function, Dirichlet's condition, and statement of Fourier Theorem. Fourier series of periodic function of period 2*l*, Fourier series of functions having points of discontinuity.

Applications: Fourier series of typical waveforms -saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform. Practical harmonic analysis.

Fourier Transforms: Concept of finite Fourier Transform, Infinite Fourier Transform**:** Fourier Sine and Cosine transforms and properties. Inverse Transforms. (**9L+4T)**

Suggested Reading: half range Fourier series, Convolution theorem, Parseval's identities for Fourier transform and Physical Significance of Parseval's identities.

UNIT-4

PARTIAL DIFFERENTIAL EQUATIONS [9 hours]

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). Applications: One-dimensional heat equation and wave equation (without proof), various possible solutions of these by the method of separation of variables. **(7L +2T)**

Suggested Reading**:** Direct integration method. Method of separation of variables. D'Alembert's solution of wave equation. Solution of boundary value problems using Fourier Transform method.

UNIT- 5

CALCULUS OF VARIATIONS **[7 hours]**

Variation of a functional, Euler's equation, variational problems.

Applications: Geodesics on a plane, hanging cable problem, Geodesics of a right circular cylinder. Brachistochrone problem.

Isoperimetric problems. **(5L +2T)**

Suggested Reading: Geodesics of a right circular cone, minimal surface of revolution.

MATHEMATICS LAB

- Solution of system of algebraic equations using Gauss Seidel method
- LU decomposition of matrices.
- Eigenvalues and eigenvectors of matrices.
- Largest, smallest eigenvalue and the corresponding eigenvectors of a matrix.
- Diagonalisation of matrices

Bibliography

Text Books

(1)Higher Engineering Mathematics, B.S. Grewal, 43rd edition, 2014, Khanna Publishers.

(2)Advanced Engineering Mathematics, Dennis G. Zill and Cullen, 4th edition, 2011, Jones and Bartlett India Pvt. Ltd.

Reference Books

(1) Advanced Engineering Mathematics, Erwin Kreyszig, 10th edition Vol.1 and Vol.2, 2014, Wiley-India.

(2) Higher Engineering Mathematics, B.V. Ramana, 7th reprint, 2009, Tata Mc. Graw Hill.

(3)Numerical methods for Scientific and Engineering Computation, M. K. Jain, S.R. K Iyengar, R. K. Jain, 6th edition, 2010, New Age International (P) Limited Publishers.

E books and online course materials

(1) Engineering Mathematics, K. A. Stroud, Dexter J. Booth, Industrial Press, 2001 http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.

(2) Advanced Engineering Mathematics, P. V. O'Neil, 5th Indian reprint, 2009, Cengage learning India Pvt. Ltd.

(3)http://ocw.mit.edu/courses/mathematics/ (online course material)

Online Courses and Video Lectures:

(1)http://nptel.ac.in/courses.php?disciplineId=111

(2)https://www.khanacademy.org/

(3)https://www.class-central.com/subject/math (MOOCS**)**

On completion of the course the student will have the ability to:

Course Code	COURSE OUTCOME (CO**)**	**PO**	**Bloom's level**
15MA3GCAPM	CO-1: Compute solution of a system of algebraic equations, algebraic and transcendental equations, and ordinary differential equations numerically.	2, 3	3
	CO-2: Demonstrate an understanding of Fourier series and Fourier transforms techniques.	2, 3, 4	4
	CO-3: Formulate boundary value problems involving one dimensional heat and wave equation.	2, 3, 4	4
	CO-4: Solve partial differential equations with appropriate boundary conditions using analytical techniques.	2, 3, 4	4
	CO-5: Use calculus of variations to find the extremal of a functional.	2, 3	3

Program Outcome:

1. Graduates will apply knowledge of Mathematics, Science and Engineering concepts to solve problems pertinent to Chemical and Biotechnology.
2. Graduates will be able to identify problems related to chemical engineering and biotechnology, analyse and derive valid conclusions with fundamental knowledge in chemistry, biology, Engineering and computation.
3. Graduates will be able to design, conduct experiments, analyse and interpret data for Investigating problems in chemical engineering, biotechnology and allied fields.

Assessment:

- Each unit consists of one full question.
- Each full question consists of three or four subdivisions.
- Five full questions to be answered.
- To set one question from Units 1, 2, 5 and two questions from Unit 3 and Unit 4

Questions for CIE and SEE will be designed to evaluate the various educational components (Blooms taxonomy) such as:

- Remembering and understanding the course contents (weightage: 40%)
- Applying the knowledge acquired from the course (weightage: 35%)
- Analyzing various engineering problems (weightage: 15%)
- Understanding of various system models (weightage: 5%)

COURSE TITLE	BIOCHEMISTRY & BIOENERGETICS										Credits	4			
COURSE CODE	1	5	B	T	4	D	C	B	A	B	L-T-P-S	2	1	1	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Know edge of organic chemistry, Basics of Biomolecules and Cell Biology and Genetics.

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

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

PART A: THEORY+ TUTORIAL

UNIT - 1

PRINCIPLES OF BIOENERGETICS [4L+3T]

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, Bioenergetic interconversions and thermodynamic constraints on their stoichiometrics, Simple problems.

UNIT - 2

CARBOHYDRATE METABOLISM [6L+3T]

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

UNIT - 3

PHOTOSYNTHESIS [5L+2T]

Introduction, Bacterial photosynthesis, Chloroplast/thylakoid 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

LIPID METABOLISM [6L+2T]

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

UNIT - 5

NITROGEN METABOLISM [5L+3T]

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

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

Bibliography

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 by Garett and Grisham, Thompson Learning
3. Bioenergetics by David.G.Nicolls and Styart J. Ferquson, Academic Press, Elsevier

e-books:

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

MOOCs:

1. https://www.mooc-list.com/course/principles-biochemistry-edx?static=true
2. http://nptel.ac.in/syllabus/syllabus.php?subjectId=102101002

PART B: 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 OUTCOMES (COS):

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

ASSESSMENT:

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

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

COURSE TITLE	UNIT OPERATIONS-2										Credits	6			
COURSE CODE	1	5	B	T	4	D	C	U	O	2	L-T-P-S	3	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

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

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

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

PART A: THEORY

UNIT – 1

CONDUCTIVE & CONVECTIVE HEAT TRANSFER [7 HOURS]

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

UNIT - 2

CONDENSATION AND EVAPORATION [5 HOURS]

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

UNIT - 3

BASICS OF MASS TRANSFER [7 HOURS]

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

UNIT - 4

MASS TRANSFER OPERATION – I [10 HOURS]

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

UNIT – 5

MASS TRANSFER OPERATION – II [10 HOURS]

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

Bibliography

TEXT BOOKS:

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

REFERENCE BOOKS:

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

e-books:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill. http://www.ualberta.ca/~seyedsha/Ebooks/Unit%20Operations%20Of%20Chemical%20Engineering,%205th%20Ed,%20McCabe%20And%20Smith.pdf

2. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0CEcQFjAH&url=https%3A%2F%2Fornithopter.googlecode.com%2Ffiles%2FCoulson__Richardsons_Chemical_.pdf&ei=p0iJVfLFE4XiuQTA6aTwDg&usg=AFQjCNFgBbve1dez_wkIdeYqMUfMKuuxCQ&bvm=bv.96339352,d.c2E

MOOCs:

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

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 OUTCOMES (COs):

CO 1	Apply mathematical knowledge to formulate and analyze problems related to steady state heat conduction, convection and insulation.
CO 2	Understand the working principle and construction of heat exchangers and evaporators and solve related problems.
CO 3	Analyze diffusional processes and estimate flux and mass transfer coefficients in a diffusion process.
CO 4	Explain working principle of various separation processes and equipment required.
CO 5	Apply the concepts of mechanical operations, momentum transfer, heat transfer and mass transfer operations in lab experiments.
CO 6	Demonstrate the concepts of heat and mass transfer in bioprocess.

ASSESSMENT:

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

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

Course Title	Biostatistics and Probability	Course Code	15MA4DCBSP
Credits	04	L – T – P- S	3 – 1 – 0 - 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)

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

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

COURSE DESCRIPTION: The course offers an extensive study to small and large data using various statistical methods. Emphasis is on the application to biological models.

UNIT-1

STATISTICS & PROBABILITY DISTRIBUTIONS [11 hours]

Curve fitting: $y = a + bx$, $y = a + bx + cx^2$, $y = ab^x$, Correlation and regression.

Introduction, Discrete distribution: Poisson distribution- problems, Continuous distributions: Normal, Gamma distribution, problems. **(8L+3T)**

UNIT-2

MARKOV CHAIN AND GENETIC APPLICATION [8 hours]

Introduction, 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: Hardy - Weinberg law, Wahlund's Principle, Sib mating, Selfing.

(6L+2T)

UNIT-3

DESIGN OF EXPERIMENTS [9 hours]

Principles of experimental design – Randomisation, Replication, Local Control.

Randomised block design, Completely Randomised block design, Latin Square Design, Factorial Experiments –Problems. **(7L+2T)**

UNIT-4

STATISTICAL INFERENCE - I **[9 hours]**

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

[Large sample] Test of significance for single mean, difference between two means, single proportion, difference between two proportions, and difference of two Standard deviations. **(7L+2T)**

UNIT-5

STATISTICAL INFERENCE – II **[11 hours]**

[Small sample] Test of significance for single mean, difference between two means, paired t-test, ratio of variances (F- distribution), Chi -Square distribution-goodness of fit, independence of attributes. Analysis of variance (one-way and two-way classifications). Non parametric test – Wilcoxon Rank Sum test and Kruskal – Wallis One Way Analysis of Variance by Ranks. **(8L+3T)**

Bibliography

Text Books:

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

Reference Books:

1. Wayne W. Daneil – Biostatistics: A foundation for Analysis in the Health sciences 10th edition, 2013, John Wiley & Sons.
2. Schaum's Outline of Probability and Statistics, 4th edition, 2013, Schaum's outlines
3. Biostatistics – P.N.Arora, P.K. Malhan, 2nd edition, 2013, Himalaya Publishing House.
4. Fundamentals of Biostatistics by Veer BalaRastogi- 2nd edition, 2009, Ane books Pvt. Ltd. India.

E books and online course materials

1. Statistics online computational resource wiki.stat.ucla.edu/socr/index.php/Probability_and_statistics_EBook
2. accessengineeringlibrary.com/.../schaums-outline-of-probability-and-statistics-fourth-edition.
3. Fundamentals of Statistics and Probability for Engineers, T.T. Soong, John Wiley and Sons Ltd.

4. fastebook.org/.../fundamentals-of-biostatistics-khan-and-khanum.html

Online Courses

1.http://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/

2. http://nptel.ac.in/courses/*111105041/1* NPTEL >> Mathematics >> Probability and Statistics

3. https:// www.khanacademy.org/Math

4. https:// www.class-central.com/subject/math (MOOCS)

5. E-learning: www.vtu.ac.in

Course outcomes (Cos)

	CO
CO-1	Ability to estimate the correlation of two variables and prediction of one variable from the other.
CO-2	Apply the basic principles of probability and probability distributions to the problems in Bio-technology.
CO-3	Apply the concepts of Markov chain to the field of genetics.
CO-4	Demonstrate and understanding of sampling and its various techniques.
CO-5	Draw inferences about the characteristics of population from the samples based on the parametric and non-parametric tests.

Mapping Program Outcome:

1. Graduates will apply knowledge of Mathematics, Science and Engineering concepts to solve problems pertinent to Biotechnology.
2. Graduates will be able to identify problems related to biotechnology, analyze and derive valid conclusions with fundamental knowledge in biology, Engineering and computation.
3. Graduates will be able to design, conduct experiments, analyze and interpret data for Investigating problems in biotechnology and allied fields.

Assessment:

- Each unit consists of one full question.
- Each full question consists of three or four subdivisions.
- Five full questions to be answered.
- To set one question from Units 2, 3, 4 and two questions from Unit 1 and Unit 5

Questions for CIE and SEE will be designed to evaluate the various educational components (Blooms taxonomy) such as:

- Remembering and understanding the course contents (weightage: 40%)
- Applying the knowledge acquired from the course (weightage: 35%)
- Analyzing various engineering problems (weightage: 15%)
- Understanding of various system models (weightage: 5%)

COURSE TITLE	ENVIRONMENTAL BIOTECHNOLOGY										Credits	3			
COURSE CODE	1	5	B	T	4	D	C	E	B	T	L-T-P-S	3	0	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

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

COURSE DESCRIPTION: This course describes the major environmental issues and the various biotechnological applications that are currently being used for sustainability of environment.

COURSE OBJECTIVES: To enable the students to gain knowledge on the various environmental issues and the application of biotechnological concepts /principles for betterment (remediation) and sustainability of environment.

UNIT - 1

BIOACCUMULATION OF TOXICANTS [5 HOURS]

Introduction, characteristics of Xenobiotics, Relationship of Bioaccumulation with Chemical Structure, Ecophysiology of Bioaccumulation, Process of toxicants uptake-kinetic aspects , Factors affecting bioaccumulation, doses of toxicants, dose–effect relationships ,quantal response & graded responses , application of dose-effect relationship. measurement of bioaccumulation. Kinetic modelling of bioaccumulation.

UNIT - 2

BIODEGRADATION AND BIOREMEDIATION OF TOXICANTS [11 HOURS]

Biodegradation of organic pollutants (aerobic and anaerobic degradation of biopolymers, co-metabolic degradation of organo pollutants), biodegradation of pesticides : fate of pesticides in environment, microbial adaptations to pesticide contaminated soils , enzymes catalyzing pesticide degradation reactions. microbial transformations of pesticides(β oxidation, oxidative dealkylation, thioetheroxidation,decarboxylations,epioxidations,hydroxylations,ring cleavages, hydrolysis, nitro reactions.) microbial transformations of heavy metals (heavy metal toxicity, microbes involved, metal –microbe interactions, transformations, genetic aspects of heavy metal resistance , applications) bioleaching and biomining :(Microbes in Bioleaching, Metal Recovery, Microbial recovery of phosphate, microbial extraction of petroleum, microbial production of fuels. Bioremediation using microbes, bioremediation processes & technologies, monitoring of the efficacy of bioremediation, Phytoremediation .

UNIT - 3

BIOTECHNOLOGICAL APPLICATIONS OF GREEN CHEMISTRY [9 HOURS]

Principles of green chemistry ,significance; biofuels : need for alternate energy source (types of non-renewable and renewable energy resources, impact of conventional fuels on environment,) sources, types– producer gas, biogas, biodiesel, biomethanol, power alcohol (bioethanol), merits and demerits .; biofertilizers and biopesticides (types , characteristics & advantages , genetic transformation) ;biopolymers & bioplastics (types, characteristics & advantages, applications); Alternative feedstocks /starting materials ;Alternative reagents or transformations .

UNIT- 4

BIOLOGICAL TREATMENT OF WASTE WATER [7 HOURS]

Introduction , waste water characteristics, (Physical,chemical,biological) Waste water treatment, unit operations, design and modeling of activated - sludge process, Microbial Process for wastewater treatment, BOD, COD, Secondary treatment,microbial removal of phosphorous and nitrogen; Nutrient removal by Biomass production. Industrial waste treatment opportunities for reverse osmosis and ultra filtration. Wastewater treatment of food processing industries like sugar factories, vegetable oil industries, potato processing industries, dairy industries, beverages industries and distilleries.

UNIT - 5

SOLID WASTES MANAGEMENT [7 HOURS]

Basic aspects, characteristics of solid wastes, general composition of urban solid wastes, Methods of solid waste treatment -aerobic & anaerobic, biogas generation, biotechnological processes involving solid Hazardous wastes: Biomedical, Dairy, Pulp, Textile, leather and pharmaceutical industry wastes, petroleum waste treatment.

Bibliography

TEXT BOOKS:

1. A textbook of Environmental Chemistry and Pollution Control: S.S Dara, S.Chand & Co.
2. Textbook of Environmental Biotechnology: Pradipta Kumar Mohapatra., IK International.

REFERENCE BOOKS:

1. Environmental Biotechnology: Foster C.F., John ware D.A., Ellis Horwood Limited, 1987.
2. Environmental Biotechnology: Indu Shekhar Thakur, IK Publishers, 2006.
3. Fuels from Waste: Larry Anderson and David A Tillman. Academic Press, 1977.

4. Bioprocess Technology- fundamentals and applications: S O Enfors &LHagstrom, RIT, Stockholm, 1992.

e-books:

1. ibrary.umac.mo/ebooks/b28045907.pdf
2. http://www.springer.com/in/book/9781588291660

MOOCs:

1. http://nptel.ac.in/syllabus/syllabus.php?subjectId=120108005

COURSE OUTCOMES (COS):

CO 1	Understand the fundamental mechanisms involved in the interaction of living and non-living systems with toxicants.
CO 2	Analyze applicability of phenomena such as bioremediation and bioaugmentation.
CO 3	Understand impact of renewability concept in present day scenario.
CO 4	Select design processes in treatment of waste water and solid wastes

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

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

COURSE TITLE	BASICS OF COMPUTER APPLICATIONS										Credits	5			
COURSE CODE	1	5	B	T	4	D	C	B	C	A	L-T-P-S	2	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Basics of computer concepts, Molecular Biology

COURSE DESCRIPTION: This course imparts the knowledge about creating and accessing databases using SQL as well as HTML and XML documents and their scope in biotechnology field. Students will be able to write Perl scripts which are important in Bioinformatics and other biological science applications.

COURSE OBJECTIVES: The objective of the course is to make graduates comprehend the concepts like SQL, HTML, XML and Perl languages and prepare them to work individually and as a team in a multidisciplinary environment.

PART A: THEORY

UNIT - 1

BASICS OF DATABASES **[6 HOURS]**

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

UNIT - 2

INTERNET **[4 HOURS]**

Network architecture. Internet: internet addresses, Internet protocol suit - transport layer protocols, File transfer protocol, internet access and applications. HTTP, web services, WWW proxies, applications on the web.

UNIT - 3

HTML and XML **[4 HOURS]**

HTML : Fundamentals, Basic Tags, Elements, Attributes, Formatting, Phrase Tags, Images, Tables, Lists, Frames, Colours, Forms, Style sheets, HTML JavaScript.XML: Fundamentals, Namespaces, Syntax and applications.

UNIT - 4

INTRODUCTION TO PERL **[7 HOURS]**

An overview of Perl: Escape sequences, Numerical data types, strings in Perl, Operators, Perl statements: Introduction to statements, Types - Input/Output statements, conditional statements, looping, and jumping statements. Lists: Introduction to lists and accessing list values. Arrays : initilising array, adding elements to an array, accessing single and multiple elements from an array. Array manipulating functions (pop, push, shift, unshift, splice, sort). Hashes: Introduction to Hashes, creating a hash, working with hashes, adding, changing and accessing hash values. Regular expressions: Introduction to regular expressions, patterns, metacharacters, modifiers, grouping and alteration. Matching, substitution, translation and binding operators.

UNIT - 5

PERL FOR BIOINFORMATICS **[5 HOURS]**

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

Bibliography

TEXT BOOKS:

1. Microsoft SQL Server 2008 For Dummies, Mike Chapple, 2009, John Wiley & Sons Publisher
2. Fundamentals of Database systems, Ramez Elmarsi, and Shamkant B. Navathe, Durvasula V.L.N.Somayajulu and Shyam K.Gupta, Pearson Education.
3. Steven Holzner, XML: A Beginner's guide: Go Beyond the basics with Ajax, XHTML, XPath2.0, XSLT 2.0 and XQuery, McGraw Hill Professional, Ist Edition, 2008.
4. Beginning Perl for Bioinformatics, James Tisdall, Publisher: O'Reilly, First Edition October 2001
5. Perl cook book by O'Reilly & Associates, second edition, 2003.

REFERENCE BOOKS:

1. Learning Perl (III edition) by Tom Christiansen, Jon Orwant, Larry Wall, 2001.
2. SAMS teach SQL yourself in 10 minutes by Ben Forta, 3rd Edition
3. SQL Queries for more mortals: A hands on guide to data manipulation in SQL by Michael J. Hernandez and John L. Viescas (2000).
4. Internet:The complete reference by Margaret Levine young, Tata McGraw Hill, 1999.
5. A First course in database systems by Jeffrey D. Ullman and Jennifer D. Widon. (2nd Ed.)

e-books:

1. www.free-ebooks.net/ebook/Build-and-Design-a-Website-HTML-CSS
2. www.onlineprogrammingbooks.com/sql/
3. http://www.freebookcentre.net
4. http://www.getfreeebooks.com

MOOCs:

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

PART B: BASICS OF COMPUTER APPLICATIONS LAB: (2 hrs/week)

1. A Program to implement Data Definition language
2. A Program to implementation on DML, TCL and DRL
3. A Program to implement Nested Queries & Join Queries
4. A Program to implement Views
5. A Program to illustrate basic HTML tags
6. A Program to illustrate Table tag
7. A Program to illustrate Form tag
8. A Program to illustrate Hyper Link tag
9. A Program to illustrate ordered and unordered List tag
10. A Program to illustrate CSS (cascading style sheet)
11. A Program to illustrate img tag and Embedded Multimedia
12. Perl Program for Pattern Matching

COURSE OUTCOMES (COS):

CO 1	Apply the concept of SQL to create and access the databases and can develop a database
CO 2	Comprehend the concept of networks, internet, and web services.
CO 3	Apply the concept of HTML and XML to create a website.
CO 4	Describe the different datatypes of PERL and its functions and write the PERL scripts for various biological and allied applications.
CO 5	Apply the concepts of programming for emerging technologies

ASSESSMENT:

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

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

COURSE TITLE	PROCESS PRINCIPLES AND CALCULATIONS										Credits	3			
COURSE CODE	1	5	B	T	4	D	C	P	P	C	L-T-P-S	2	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Engineering chemistry & mathematics, unit operations.

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

COURSE OBJECTIVES: To enable the students to formulate and solve problems related to

(1) Energy balances of chemical reactions (2) stoichiometric equations for microbial growth & product formation and (3) material balances in steady state unit operations

UNIT – 1

INTRODUCTION TO BIOPROCESS CALCULATIONS [3L+2T]

Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases.

UNIT - 2

HUMIDITY AND HUMIDITY CHART [5L+2T]

Vapour-Pressure concept, Saturation, Partial saturation, molal, absolute humidity concepts. Humidity chart

UNIT – 3

MATERIALS BALANCE WITHOUT REACTION [6L+3T]

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

UNIT – 4

STEADY STATE MATERIAL BALANCE WITH REACTION [6L+3T]

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

UNIT - 5

ENERGY BALANCE [6L+3T]

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

Bibliography

TEXT BOOKS:

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

REFERENCE BOOKS:

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

e- books:

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

MOOCs:

https://www.mooc-list.com

COURSE OUTCOMES (COs):

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

ASSESSMENT:

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

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

Course Title	BIOANALYTICAL TECHNIQUES										Credits	4			
Course Code	1	6	B	T	5	D	C	B	A	T	L-T-P-S	3	1	0	0

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

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

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

UNIT - 1

CHROMATOGRAPHIC TECHNIQUES [9L + 3T]

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

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

UNIT - 2

ELECTROPHORESIS [7L + 2T]

Principle, factors affecting the electrophoretic mobility, Moving boundary, paper and cellulose acetate electrophoresis, Types of gels: starch, agarose, polyacrylamide and agarose-acrylamide. Solubilizers, electrophoretic procedures, detection, recovery, estimation and applications. Specialized electrophoretic techniques (principle, method and applications): capillary electrophoresis, discontinuous (disc) gel electrophoresis, native PAGE, SDS-PAGE, high voltage electrophoresis, isoelectric focusing and pulsed field gel electrophoresis.

UNIT - 3

BIOPHYSICAL TECHNIQUES [9L + 3T]

Principle, instrumentation and applications of Rayleigh scattering, ultra-centrifugation, viscometry. SEM, TEM, Scanning tunneling microscopy, AFM, luminescence (fluorescence & phosphorescence), Isothermal and differential calorimetry, Mass spectrometry: LC-MS, MALDI-TOF, Electrophysiology techniques: Voltage Clamp and Patch Clamp, Flow cytometry.

UNIT - 4

STRUCTURE DETERMINATION OF MACROMOLECULES [9L + 3T]

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

UNIT - 5

RADIOISOTOPE TECHNIQUES [5L + 2T]

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

1. Biophysics – An Introduction by Cotterill, Wiley Student Edition
2. Foundations of Biophysics by A.L. Stanford, 1st edition.
3. Principles of protein structure by G Schulz and R H Schrimer (Springer Verlag) 1st edition.
4. Principles of nucleic acid structure by Sanger (Springer Verlag) 1st edition.

5. Introduction to Protein Science by Arthur M Lesk (OUP): oxford 2nd edition
6. Biological Spectroscopy by J. D. Campbell and R. A.Dwek, Benjaman-cummings 1st edition
7. Proteins – Structure & Molecular Properties by Creighton, Freeman N H;2nd edn.

e-BOOKS

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson

https://books.google.co.in/books?isbn=052165873X

2. Biophysical Techniques by Iain Campbell

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

MOOCs

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

COURSE OUTCOMES

1. Select technique (s) that can be applied for a biomolecule separation and elucidate the principle and method. (PO1,5)
2. Select technique (s) that can be applied for a biomolecule purification and elucidate the principle and method. (PO1,5)
3. Select and apply suitable techniques for identification of biomolecules. (PO1,5,12)
4. Select and apply suitable techniques for characterization of biomolecules. (PO1,5,12)

Course Title	BIOINFORMATICS										Credits	6			
Course Code	1	6	B	T	5	D	C	B	I	N	L-T-P-S	3	0	1	2

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

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

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

PART A: THEORY

UNIT - 1

BIOINFORMATIC RESOURCES AND SEARCH TOOLS [7 L]

Introduction to Bioinformatics, Bioinformatics resources: NCBI, EBI, ExPASy, RCSB; Significance of databases towards informatics projects,

Sequence and structure databases: GenBank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, and TrEMBL.

Biomolecular sequence file formats: Gene bank flat file, Protein Data Bank (PDB) flat file, FASTA Format, PIR Format, MMDB, SCOP, Pfam. Specialized databases: OMIM, Medical databases, KEGG, EST databases.

UNIT - 2

SEQUENCE ANALYSIS [10 L]

Sequence similarity search: Introduction; FASTA, BLAST, Low-Complexity Regions, Repetitive Elements. scoring matrices: Amino acid scoring matrices; PAM, BLOSUM, Comparison between PAM and BLOSUM,. Sequence Alignment: Introduction, The evolutionary basis of

sequence alignment. Alignment algorithms: Pair wise alignment – Dotplot, Global alignment ,local alignment, Gaps, Gap scores and Gap penalties,

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

UNIT - 3

PHYLOGENETIC ANALYSIS AND PREDICTIVE METHODS [10 L]

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

UNIT - 4

ANALYTICAL TOOLS FOR GENOMIC AND PROTEOMIC STUDIES [6 L]

Predictive Methods: Genomic and proteomic sequence acquisition and analysis, Web based tools; Restriction mapping: Utilities, various steps involved, Web based tools; Primer design: need for tools, Primer design tools; Structure Visualization and Graphical representation of molecular structures, Usages of visualization software available in public domain like Rasmol, Pymol, SpdbViewer, Cn3D. Conceptual numericals.

UNIT - 5

MOLECULAR MODELING, DRUG DESIGN AND DISCOVERY [6 L]

Molecular dynamics- modelling and simulations: basic concepts including force fields, protein-protein, protein-nucleic acid, protein-ligand interaction; Drug design and discovery: an overview. Protein Structure Prediction and critical Assessment, Superposition of proteins using different tools, RMSD, protein conformational analysis. QSAR. Docking and Virtual Screening. Energy Calculations (no derivation). Pharmacophore prediction based on the docking analysis.

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

e-BOOKS

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

MOOCs

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

COURSE OUTCOMES

1. Describe various bioinformatics resources and classify biological databases and their file formats. (PO1)
2. Construct sequence alignment, analyze and interpret the data. (PO2, PO4, PO5)
3. Perform phylogenetic analysis and interpret the data. (PO2, PO4, PO5)
4. Perform sequence analysis, restriction site mapping, primer designing and visualization of protein structures. (PO2, PO4, PO5)
5. Comprehend and apply the in silico tools towards drug discovery. (PO1, PO5)

PART B: BIOINFORMATICS LABORATORY

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

Course Title	REACTION ENGINEERING										Credits	3			
Course Code	1	6	B	T	5	D	C	R	E	N	L-T-P-S	2	1	0	0

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

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

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

UNIT - 1

REACTION KINETICS **[5L+3T]**

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

UNIT - 2

IDEAL BIOREACTORS **[6L+3T]**

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 - 3

NON-IDEAL BIOREACTORS [6L+3T]

Non-ideal reactors: residence time distribution studies, pulse and step input response of reactors, RTD's for CSTR and PFR, calculations of conversions for First order reactions, One parameter models - tanks in series and dispersion models. Zero Parameter Models, Conceptual numericals

UNIT - 4

DESIGN AND ANALYSIS OF BIOREACTORS [6L+2T]

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

UNIT - 5

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

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

e-BOOKS

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

MOOCs

1. http://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biological-reaction-engineering-spring-2007/syllabus/
2. http://www.nptelvideos.in/2012/11/chemical-reaction-engineering.html

COURSE OUTCOMES

1. Compute chemical reactions rates using different methods. (PO1, PO2)
2. Derive design equations for different reactors at steady state as well as analyze and solve related problems. (PO1, PO2)
3. Estimate the residence time distributions for various non-ideal reactors and compare various models. (PO1, PO2)
4. Select bioreactor for a given criteria and describe scale-up process. (PO1, PO5)
5. Identify, interpret and solve problems related to microbial kinetics for biochemical engineering applications. (PO1, PO2)

Course Title	GENETIC ENGINEERING										Credits	6			
Course Code	1	6	B	T	5	D	C	G	E	N	L-T-P-S	3	0	1	2

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

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

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

UNIT - 1

MOLECULAR TOOLS FOR GENE CLONING [6 L]

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

UNIT - 2

VECTORS FOR GENE CLONING [10 L]

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

UNIT - 3

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

Isolation and purification of nucleic acids (genomic/plasmid/phage DNA and RNA), Polymerase chain reaction (PCR) variants and applications, Nucleic acid detection: Labeling (DNA and RNA by radio- and fluorescent methods), Southern blotting, northern blotting, Southwestern blotting and western blotting. Nucleic acid mutagenesis in vivo and in vitro, Construction of

cDNA library, Construction of Genomic library, Screening of DNA libraries: Sequence-dependent screening (colony and plaque hybridization) and immunological screening.

UNIT - 4

GENE TRANSFER TECHNIQUES [6 L]

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

UNIT - 5

APPLICATIONS [7 L]

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

1. From Genetics to Gene Therapy – the molecular pathology of human disease by David S Latchman, BIOS scientific publishers, 1994, 1st edition

2. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick, B R, Pasternak .J J, 2003, Third edition, DC ASM Press.

e-BOOKS

1. Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.
2. Molecular Cell Biology. 4th edition. Lodish H, Berk A, Zipursky SL, et al.New York: W. H. Freeman; 2000.

MOOCs

1. http://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinant-dna/
2. http://nptel.ac.in/courses/102103013/3

PART B: GENETIC ENGINEERING AND IMMUNOTECHNOLOGY LABORATORY

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

COURSE OUTCOMES

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

Course Title	IMMUNOTECHNOLOGY										Credits	3			
Course Code	1	6	B	T	5	D	C	I	M	M	L T P S	3	0	0	0

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

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

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

UNIT - 1

INTRODUCTION TO IMMUNE SYSTEM [6 L]

Historical development, Overview of immune response, Innate and Adaptive immunity, Passive and active immunity, Humoral and Cell mediated immunity, Organs of Immune System, role of macrophages, neutrophils, Basophils, eosinophils and Dendritic cells.

UNIT - 2

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

T-CELLs and NK cells: T-cell types, development, T cell receptors, Co receptors and other surface markers, T-B interaction. T helper cells: activation, differentiation and cytokine production. CTLs and NK cells: activation, differentiation and function. **[10 L]**

UNIT - 3

IMMUNE SYSTEM IN HEALTH & DISEASE

The Complement System: Classical, Alternate and MBL –pathways. Hypersensitivity Reactions-Type I,II, II and IV, Immunodeficiency disorders: Primary and Secondary, Autoimmunity: autoimmune disorders, mechanism, cancer immunotherapy

Transplantation: mechanism of transplant rejection, tissue typing, prevention of transplant rejection, Graft versus host reaction, Immune tolerance **[10 L]**

UNIT – 4

VACCINES AND THERAPEUTIC ANTIBODIES

Vaccines: Design strategies, Whole organism, Subunit and synthetic vaccines

Therapeutic Antibodies: Immuno-toxins, antibody hetero-conjugates, chimeric and humanized, minibodies, antibody mimics (adnectins, affibodies). Production of polyclonal antibodies, poduction of monoclonal antibodies by hybridoma technology and r-DNA technology **[6 L]**

UNIT – 5

IMMUNOTECHNIQUES [7 L]

Antigen – Antibody Reactions, Affinity, Avidity, Cross-Reactivity, Immunoprecipitations-Precipitation Reactions, Agglutination Reactions, Radioimmunoassay, Enzyme-linked Immunosorbent Assay, Western Blot, Immuno-electrophoresis. Immuno-fluorescence, Immuno-electron Microscopy.

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

e-BOOKS

1. Immunology: With STUDENT CONSULT Online Access, 8e (Immunology (Roitt)) 8th Edition by David Male MA PhD (Author), Jonathan Brostoff MA DM DSc(Med) FRCP FRCPath (Author), David Roth MD PhD (Author), Ivan Roitt.
2. Janeway, Charles A., et al. Immunobiology: The Immune System in Health and Disease. New York, NY: Garland Science, 2004. ISBN: 9780443073106.

MOOCs

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

COURSE OUTCOMES

1. A. distinguish various types of antibody molecules and explain their production and application as therapeutics (PO1)

B. Draw structure of immune cells and organs, relate their role in immune defense (PO1)

C. Distinguish MHC class I and class II and illustrate their role in antigen processing pathways. (PO1)

2. Describe the role of immune system in health, disease and transplant rejection (PO1 and PO6)

3. Describe various parameters in design of vaccines (PO12 and PO6)

4. Conduct experiments involving detection and quantification of antigens and antibodies. (PO4)

Course Title	ANIMAL BIOTECHNOLOGY										Credits	3			
Course Code	1	6	B	T	5	D	E	A	B	T	L-T-P -S	3	0	0	0

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

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

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

UNIT- 1

ESSENTIALS FOR ANIMAL CELL CULTURE [9 L]

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

UNIT - 2

ANIMAL CELL CULTURE TECHNIQUES [7 L]

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

UNIT - 3

CHARACTERIZATION OF CELL LINES AND TISSUES [9 L]

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

UNIT - 4

DEVELOPMENT AND USE OF TRANSGENIC ANIMALS [7 L]

Animal cloning and selection, Methods for production of transgenic animals: Retroviral vector, DNA microinjection, Engineered-embryonic stem cells, Knocking in and knocking out of genes. Gene mapping, marker assisted selection and genetic improvement of desired characters of domestic animals, IVF. Ethical & legal issues.

UNIT - 5

APPLICATIONS [7 L]

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

PRIMARY REFERENCES

1. Culture of Animal Cells by Freshney R I(2005), 5th Edn, Wiley-Liss.
2. Animal Cell Biotechnology by Spier RE and Griffiths JB (1988), Academic Press.6th edn.

SECONDARY REFERENCES

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

e-BOOKS

1. Animal Cell Biotechnology Methods and Protocols, Editors: Nigel; ISBN: 978-0-89603-547-8(Print) 978-1-59259-486-3(Online), http://link.springer.com/book/10.1385%2F0896035476
2. Animal Biotechnology, 1st Edition Models in Discovery and Translation Editor(s):Verma & Singh eBook ISBN :9780123914347, http://store.elsevier.com/Animal-Biotechnology/isbn-9780124160026/

MOOCs

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

COURSE OUTCOMES

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

Course Title	MICROBIAL BIOTECHNOLOGY										Credits	3			
Course Code	1	6	B	T	5	D	E	M	B	T	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Cell and Molecular biology, Basics of biomolecules, Biochemistry and bioenergetics, Microbiology and Environmental Biotechnology

COURSE DESCRIPTION: This course includes microbial growth kinetics, production of bio-pharmaceuticals, primary & secondary metabolites as well as energy from biomass and organic waste. This course also imparts knowledge on microbial bioremediation and bioleaching.

COURSE OBJECTIVES: This course enables students to understand microbial metabolism and growth kinetics and apply the concepts to generate energy from biomass and organic waste as well as to engineer the microbes for production of biopharmaceuticals, green chemicals and novel compounds.

UNIT - 1

INTRODUCTION TO MICROBIAL CELL CULTURE AND GROWTH KINETICS [7 L]

Introduction to industrial microbial processes, inoculum development, design & optimization of media, kinetics of cell growth; Sterilization; Modes of cell culture; Bioreactor systems including utilities; Mass transfer in Microbial processes. Scale - up of microbial processes. Instrumentation and control of process parameters.

UNIT - 2

BIOPHARMACEUTICALS FROM MICROBES/PRODUCTION OF PRIMARY AND SECONDARY METABOLITES [10 L]

Producer organisms, metabolic pathways, media employed and fermentation process for production of Solvents - Alcohol, Glycerol. Organic acids –Citric acid, acetic acid, L-ascorbic acid, lactic acid. Antibiotics – Penicillins (Penicillin),Cephalosporins (cephalosporin), Aminoglycosides (streptomycin), Tetracyclines (chlortetracycline), Macrolides (erythromycin A). Amino acids – L-glutamic acid, L-lysine, L-tryptophan.Vitamins – Vitamin B12, Riboflavin, Beta-carotene.Beverages from microbes, Microbial polysaccharides and polymers.

UNIT - 3

GREEN CHEMICALS FROM MICROBES [6 L]

Green chemicals and their advantages, Biosurfactants: Definition, classes, producer microbes, Biosynthesis, Large scale production (Medium components and conditions) and applications(domestic and industrial). Biopolymers: Polysaccharides- Bacterial and

fungal(composition and producer organisms), structural properties, Bioplastics- PHAs(PHBs), Producer organisms, metabolic pathways, media source and production

UNIT - 4

BIOMASS AND ORGANIC WASTE TO ENERGY [6 L]

Biomass and organic waste-Introduction, Sources, Composition and microbial metabolic processing. Microbial processing of biomass and spent liquor from sugar industry- molasses and its composition, metabolic pathway, processing of molasses to ethanol or alcohol (Flow/block diagram), Algal biofuels. Lignocellulosic biomass: Sources and composition, methods of pre-processing and post-processing, role of microbes and their enzymes. Microbial fuel cells: Definition, design and compartments, principal mechanism, liquid wastes as substrates, process of electricity generation and its economics.

UNIT - 5

BIOREMEDIATION AND BIOLEACHING [10 L]

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. Phytoremediation – plants capable of assimilating heavy metals. Case 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.

PRIMARY REFERENCES

1. Microbial Biotechnology Second edition, Alexander N. Glazer, Hiroshi Nikaido, Cambridge university, 2nd press edition
2. Biofuels and Bioenergy, Processes and technologies, Sunggyu Lee and YT Shah, CRC press book

SECONDARY REFERENCES

1. Principles of Fermentation technology, Second edition, Stanbury and A. Whitaker
2. Biofuels, Methods and protocols, Jonathan R. Mielenz
3. https://www.youtube.com/watch?v=2Admn5dmMqo NPTEL lecture video

e-BOOKS

1. http://www.freebookcentre.net/biology-books-download/Environmental-Biotechnology.html
2. https://www.amazon.in/Microbial-Biotechnology-Applications-Yuan-Kun-ebook/dp/B0058QN37S

MOOCs

1. https://www.mooc-list.com/course/tbp01x-technology-biobased-products-edx?static=true
2. http://ocw.mit.edu/courses/biology/7-341-harnessing-the-biosphere-natural-products-and-biotechnology-fall-2012/

COURSE OUTCOMES

1. Describe microbial growth kinetics, screening of superior producer organisms and solve related problems(PO2).
2. Formulate bioengineering strategies large scale-production of metabolic intermediates, biopharmaceuticals, industrial biocatalysts and recombinant products(PO2, PO3, PO5)).
3. Apply the mechanism of microbial metabolism in generating energy by sustainable utilisation of biomass and organic waste(PO7).
4. Relate the applications of microbes in Bioremediation and Bioleaching(PO3, PO6).

Course Title	HUMAN PHYSIOLOGY										Credits	3			
Course Code	1	6	B	T	5	D	E	H	P	H	L-T-P-S	3	0	0	0

COURSE PREREQUISITES: Basics of biomolecules, biochemistry and bio energetics, cell and molecular biology.

COURSE DESCRIPTION: This course gives insights in to physiological integration of the organ systems to maintain homeostasis. Course includes study of the circulatory, respiratory, digestive, neural, urinary, musculoskeletal and reproductive organ systems.

COURSE OBJECTIVES: The course is introduced to enable the students to understand the basic functions of various organ systems of human body to maintain homeostasis and body responses to various drug molecules, implants and other biotechnological devises.

UNIT - 1

DIGESTIVE SYSTEM **[6 L]**

Structure and functions of different components of digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of various enzymes and hormones involved in digestive process.

UNIT - 2

CIRCULATORY SYSTEM: Arterial and venous system, Heart structure and function, composition of blood and coagulation of blood. Blood groups- ABO and Rhesus system. Lymph and lymphatic System. Blood pressure, sphygmomanometer, Heart attack and stroke.

RESPIRATION: components of respiratory system, Regulation of respiration -- neural and chemical, respiratory centers, chemoreceptors, gaseous exchange. Hypoxia – types, effects. Asphyxia, Asthma, Artificial respiration. **[10 L]**

UNIT - 3

EXCRETORY SYSTEM: Overall design of urinary system: Kidney structure, selective reabsorption, active and passive transport of various substances and secretion. Renal regulation of osmolarity and volume of blood fluids. Renal Dialysis. Non excretory functions: vitamin synthesis

REPRODUCTION: Structure of sexual organs. Endocrine functions of testis. Spermatogenesis. Hypothalamic control of testicular functions. Histology of ovary. Ovarian hormones and their

functions. Oogenesis and ovulation. Formation and functions of corpus luteum. Hypothalamic control of ovarian functions. **[10 L]**

UNIT - 4

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. Sensory organs: - outline of various sensory organs and their functions. **[6 L]**

UNIT - 5

SKELETAL AND MUSCLE SYSTEM: kinds of muscles and mechanism of muscle contraction. Hormonal control mechanisms: Endocrine and exocrine systems. Classification of hormones. **[7 L]**

PRIMARY REFERENCES

1. Harper's Physiological Biochemistry by Harper et al.Mc Graw-Hill Medical 2nd Edition
2. Text Book of Medical Physiology by Elsevier, John E Hall,W.B.Saunders Co. 13th Edition

SECONDARY REFERENCES

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 publishers, 4th edition.

e-BOOKS

1. Human Physiology
   https://upload.wikimedia.org/wikipedia/commons/c/cd/Human_Physiology.pdf
2. Android App:
   https://play.google.com/store/apps/details?id=code.alphonso.android.bookviewer.books.humanphysiology&hl=en

MOOCs

1. https://www.coursera.org/course/humanphysio

2. http://nptel.ac.in/courses/102104042/1
3. https://www.coursetalk.com/providers/janux-interactive-learning-community/courses/human-physiology
4. https://www.coursera.org/learn/physiology

COURSE OUTCOMES

1. Comprehend coordinated functions of various organs of human body. (PO6)
2. Recognize and explain the physiological controls and feedback loops. (PO6)

Course Title	PLANT BIOTECHNOLOGY										Credits	3			
Course Code	1	6	B	T	5	D	E	P	B	T	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Cell and molecular biology, Basics of biomolecules, Biochemistry and bioenergetics, Microbiology and Environmental Biotechnology.

COURSE DESCRIPTION: The course emphasizes various plant cell culture techniques and their importance in biosynthesis of plant metabolites. The course also describes various clean-gene technologies for the development of transgenic plants against biotic and abiotic stresses.

COURSE OBJECTIVES: The objective of the course is to give insights into classical and modern plant biotechnology procedures for the production of healthy plants with improved characteristics and for production of biomolecules. Further students will exploit the biotechnological procedures in pharmaceutical and food industry as well as in agriculture and in ecology.

UNIT - 1

PLANT CELL CULTURE AND GROWTH KINETICS [6 L]

Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and Cell suspension culture system: methodology, kinetics of growth and, nutrient optimization; Production of secondary metabolites by plant suspension cultures; Hairy root culture; transgenic plants; Plant products of industrial importance

UNIT - 2

PLANT GENETIC ENGINEERING [9 L]

Induction to Plant Genetic Engineering: Types of plant vectors and their use - Particle bombardment, electroporation, microinjection. Agrobacterium mediated transformation – Technique and applications. Ti and Ri-plasmids as vectors.Screening and selection of transformants – PCR and hybridization methods.Viruses as a tool to delivery foreign DNA.Transformation of monoctos.Mechanism of transgene interaction - Transgene stability and gene silencing.Generation and maintenance of transgenic plants.

UNIT - 3

PLANTS FOR BIOTIC AND ABIOTIC STRESSES [9 L]

Introduction to biotic stresses, types. Application of plant transformation – Bt genes, Structure and function of Cry proteins – mechanism of action, critical evaluation. Non-Bt like protease inhibitors, alpha amylase inhibitor, Baculoviruses as biopesticides, Transgenic technology for development of virus, bacterial and fungal resistance plants.

Abiotic stress – 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 - 4

MOLECULAR FARMING IN PLANTS [6 L]

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

UNIT - 5

NITROGEN FIXATION AND ALGAL TECHNOLOGIES [9 L]

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.

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 macroalgae for agar agar, alginates and other products of commerce and their uses.Mass cultivation of microalgae as a source of protein and feed.

PRIMARY REFERENCES

1. Plant Cell Culture: A Practical Approach by R.A. Dixon & Gonzales, IRL Press.

2. Plant biotechnology the genetic manipulation of plants, Nigel W. Scott, Mark R, Fowler, 2nd Edition

SECONDARY REFERENCES

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

e-BOOKS

1. http://onlinelibrary.wiley.com/doi/10.1002/9780470282014.fmatter/pdf
2. https://books.google.co.uk/books/about/Introduction_to_Plant_Biotechnology.html?id=RgQLISN8zT8C

MOOCs

1. Applications of plant biotechnology in crop improvement, http://nptel.ac.in/courses/102103016/

COURSE OUTCOMES

1. Apply different methods for transformation of plants, including their specific advantages and applications (PO2).
2. Plan ideal genetic engineering strategies for the betterment of forestry, agriculture, and for the production of novel compounds, biopharmaceuticals and bio-fuels(PO3, PO5 PO7).
3. Adopt current regulations for the production and use of GMOs(PO6).
4. Use alternative cost-effective plant biotechnology methods that can replace genetic modification(PO7).

Course Title	BIOPROCESS TECHNOLOGY										Credits	6			
Course Code	1	6	B	T	6	D	C	B	P	T	L-T-P-S	3	0	1	2

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

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

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

PART A– THEORY

UNIT - 1

INTRODUCTION TO FERMENTATION TECHNIQUES [7 L]

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

UNIT - 2

FERMENTER AND MEDIA FORMULATION [10 L]

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

UNIT - 3

SCOPE OF DOWNSTREAM PROCESSING [8 L]

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

UNIT - 4

MEMBRANE ENRICHMENT OPERATIONS [7 L]

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

UNIT - 5

SECONDARY PRODUCT SEPARATION TECHNIQUES AND PRODUCT RECOVERY [7 L]

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

e-BOOKS

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

MOOCs

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

COURSE OUTCOMES

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

PART B – BIOPROCESS TECHNOLOGY LABORATORY

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

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

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

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

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

PART A: THEORY

UNIT - 1

FUNDAMENTALS OF ENZYME ACTIVITY AND METHODS OF EXTRACTION PURIFICATION [6L+2T]

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

UNIT - 2

ENZYME KINETICS [5L+2T]

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

UNIT - 3

BIOCATALYTIC FUNCTIONS [6L+3T]

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

UNIT - 4

ENZYME IMMOBILIZATION TECHNIQUES [4L+3T]

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

UNIT - 5

ENZYME ENGINEERING [5L+3T]

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

PRIMARY REFERENCES

1. Fundaments of Enzymology by Nicholas C Price and Stevens Oxford Press, 3rd edition
2. Enzymes – Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer, Wood head publishing, 2nd edition.
3. Biotransformations in organic synthesis by Faber, springer-verlags, 6th edition
4. Enzymes in Industry: Production and Applications by W. Gerhartz, VCH Publishers, NY, 1990
5. Enzyme Technology by M.F. Chaplin and C. Bucke, Cambridge university press 1990.

SECONDARY REFERENCES

1. Purifying Proteins for Proteomics by Richard J Simpson, IK International, 2004
2. Proteins and Proteomics by Richard J Simpson, IK International, 2003
3. Enzymes by Dixon and Webb prentice Hall press. 3rd edition.
4. Principles of Enzymology for technological Applications by Butterworth Heinemann Ltd.Oxford (1993).

5. Biocatalyst for Industry by J.S. Dordrick, Plenum press, New york 1991

e-BOOKS

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

MOOCs

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

PART B: ENZYME TECHNOLOGY LABORATORY

I Isolation of enzymes

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

II Purification and characterization of enzymes

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

III Enzyme kinetics

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

VI Immobilized enzymes

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

COURSE OUTCOMES

1. Select appropriate methods for isolation, purification and characterization of enzymes and solve related problems (PO1 & PO2).
2. Analyze and solve problems related to kinetics of enzymatic reactions (PO2).

3. Compare and contrast methods in enzyme catalysis and interpret the related data (PO1).
4. Illustrate immobilization techniques and their applications (PO1 & PO7).
5. Comprehend the applications of nonconventional media in enzyme catalysis and design the methods for the creation of novel enzymes (PO1 & PO3).
6. Design, conduct experiments, analyse and interpret results related to enzyme reaction kinetics (PO1, PO3, PO4 & PO7).

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

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

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

COURSE OBJECTIVES:

The objective of this course is to provide insights into high-throughput DNA sequencing techniques and contemporary approaches for genome sequencing. The course also gives insights into methods of analysis of genome, transcriptome and proteome. This course provides a platform to understand the networks underlying the cellular functions of living organisms.

UNIT - 1

GENOME SEQUENCING [7 L]

Genome organization, sizes and C-value paradox, need for whole genome sequencing, sequencing techniques: fluorescent automated, pyro sequencing, Nano pore and DNA-chip methods. Sequencing large genomes. Next generation sequencing technologies: steps involved in MPS, Hybrid capture, Third generation sequencers. Port-data generation analysis sequencing simple genomes- Shotgun sequencing and sequence alignment.

UNIT - 2

GENOME MAPPING [6 L]

Need for mapping, Genetic mapping of Bacterial genomes, physical techniques: Restriction mapping, optical mapping, hybridization mapping (FISH and FISH amplification), STS and EST mapping, Sequence alignment of large genomes: directed shotgun approach, clone-contig approach.

UNIT - 3

GENOME ANALYSIS [10 L]

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

UNIT - 4

QUANTITIVE PROTEOMICS [10 L]

Protein extraction, quantification Cell-free protein production, Tag-based protein purification, resolution of proteins: 2DE –IEF Second dimension, Staining and gel analysis, Fluorescence 2-D Difference Gel Electrophoresis (DIGE), and data analysis MALDI, and SELDI, Tandem Mass Spectrometry for Protein Identification and Peptide Mass finger printing, data analysis quantitative proteomics: iTRAQ, SILAC, isotope-Coded Affinity Tagging (ICAT), MS for PTM analysis, Application of quantitative proteomics.

UNIT - 5

INTERACTOMICS [6 L]

Techniques to study protein-protein Interactions: Yeast Two-Hybrid (YTH), Immunoprecipitation (IP), Protein microarrays, Label-free nanotechnologies: Surface Plasmon Resonance (SPR), AFM, of carbon nanotubes & nanowires, Electrochemical Impedance Spectroscopy (EIS), MEMS cantilevers.

PRIMARY REFERENCES

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

SECONDARY REFERENCES

1. A Primer of Genome Science by Greg Gibson and Spencer V, Third Edition, Muse,February 2009
2. Proteomics in Practice: A Guide to Successful Experimental Design, R. Westermeier, T. Naven, H-R. HÃ¶pker, Wiley-VCH, 2008.

e-BOOKS

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

MOOCs

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

COURSE OUTCOMES

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

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

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

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

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

UNIT - 1

INTRODUCTION AND REGULATORY GUIDELINES IN PHARMACEUTICAL BIOTECHNOLOGY [7 L]

Introduction to biopharmaceuticals and pharmaceutical biotechnology, Drug development and Economics, Fundamental principles and practical processes involved in preclinical and early proof-of concept clinical development of a chemical or biological entity. Regulatory authorities - Quality assurance and Pharmaceutical Regulations, GMP, CGMP, GLP, GCP, TQM, ISO-9000, process validation, ICH guidelines, Indian FDA regulations.

UNIT - 2

DRUG MANUFACTURE AND FORMULATION [7 L]

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

UNIT - 3

DRUG METABOLISM [10 L]

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

UNIT - 4

TOXICOLOGY [9 L]

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

UNIT - 5

APPLICATIONS OF BIOTHERAPEUTICS [6 L]

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

PRIMARY REFERENCES

1. The Theory and Practice of Industrial Pharmacy by Lachman L, CBS publication-6th edition.
2. Basic and Clinical Pharmacology by Bartram G. Katzung, McGraw Hill Publications, 2004 (Chapter 5), 11th edition.
3. Biopharmaceuticals: Biochemistry and Biotechnology by Gary Walsh 2nd edition, wiley publisher.

4. Process validation in Manufacturing of Biopharmaceuticals: Guidelines, Current Practices and Industrial Case Studies by Anurag S. Rathore, Gail SoferProcess CRC press-3rd edition.

SECONDARY REFERENCES

1. Pharmacology by Rang H. P, 8th edition,Elsevier publication.
2. Pharmaceutical biotechnology: an introduction for pharmacists and pharmaceutical scientists by Daan J. A. Crommelin, Taylor & Francis, 2nd edition.
3. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs by Rodney J. Y. Ho, Milo Gibaldi. Contributor Rodney J. Y. Ho, Milo Gibaldi, Wiley Blackwell-2nd edition.

e-BOOKS

1. Bio-pharmaceuticals. Biochemistry and Biotechnology by Dr. Gary Walsh
2. Essential of Pharmaceutical Chemistry Written by Donald Cairns
3. http://www.bpj-bd.com/

MOOCs

1. https://www.mooc-list.com/
2. https://www.mooc-list.com/course/drug-discovery-development-commercialization

COURSE OUTCOMES

1. Outline the drug development process, its economics and regulatory guidelines. (PO6, PO8)
2. Describe the concepts of tablet manufacturing, formulation, dosage forms and modes of drug delivery (PO6)
3. Distinguish different phases of drug and toxicants metabolism as well as apply concepts of pharmacokinetics and pharmacodynamics in drug development process. (PO5, PO6)
4. Relate application of biopharmaceuticals for different therapeutic conditions. (PO1, PO6)

Course Title	PROCESS CONTROL & AUTOMATION										Credits	4			
Course Code	1	6	B	T	6	D	C	P	C	A	L-T-P-S	2	1	1	0

COURSE PRE-REQUISITES: Engineering Mathematics, Unit Operations1, Unit Operations 2, Reaction Engineering

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

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

PART A: THEORY

UNIT - 1

INTRODUCTION TO BIOPROCESS CONTROL [3L+2T]

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

FIRST ORDER SYSTEMS [5L+3T]

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

UNIT - 3

SECOND ORDER SYSTEMS [5L+2T]

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

CLOSED LOOP CONTROL SYSTEMS [7L+3T]

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

BIOPROCESSE DYNAMICS, STABILTY AND AUTOMATION [6L+3T]

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, basics of
industrial automation systems: PLCs, SCADA and Distributed control systems
(DCS), their features and applications.

PRIMARY REFERENCES

1. Process System analysis and Control by Donald R Coughanowr, 2nd Edition,. McGraw-Hill, 1991
2. Chemical Process Control by George Stephanopoulos, Prentice-Hall of India, 1999, 4th edition.

SECONDARY REFERENCES

1. Process dynamics and control by D E Seborg, T F Edger, John Wiley, 1989, 2nd edition
2. Essentials of Process Control by Luyben and Luyben, Mcgraw-hill, 1997, International editions.
3. Process Modeling, Simulation and Control by William Luyben, Mcgraw-hill-2nd edition.
4. Biochemical Engineering Fundamentals by Bailey and Ollis, Mcgraw Hill- 2nd edition. 1986.
5. Bioprocess Engineering by Shuler and Kargi Prentice Hall, 1992, 2nd edition

6. Bioprocess Engineering Principles by Pauline M. Doran, 1995, Academic press-2nd edition

e-BOOKS

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

MOOCs

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

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)
14. Tuning of Pressure controller (ZN and CC methods) and responses of tuned P, PI and PID controllers
15. Control of DO (dissolved oxygen level)
16. Control of Agitation (to monitor DO since they are interlinked)

COURSE OUTCOMES

1. Classify automatic process control systems and solve problems related to Laplace Transform (PO1, 2).
2. Deduce transfer function for various systems as well as analyze and interpret the responses (PO1,2)
3. Comprehend the working principle of various controllers, final control elements and solve related problems (PO1, 2)
4. Analyze the stability of system using different tools and techniques(PO2,5)
5. Measure and control the various physical parameters using controllers (PO4,5)

Course Title	METABOLIC ENGINEERING										Credits	3			
Course Code	1	6	B	T	6	D	E	M	T	E	L-T-P-S	3	0	0	0

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

COURSE DESCRIPTION: This course includes methods for metabolic characterization (genome, transcriptome, proteome, metabolome and fluxome), comprehensive models for cellular reactions, regulation of metabolic pathways, metabolic flux analysis and applications of metabolic flux analysis. This course also includes methods for the experimental determination of metabolic fluxes by isotope labelling, metabolic control analysis, metabolic design (gene amplification, gene-disruption, randomized and targeted strain development) and metabolic Engineering in practice.

COURSE OBJECTIVES: This course provides insight into the fundamentals of metabolic engineering in strain improvement programs to increase the yield of a target product or reduce or eliminate the production of undesired impurities. This course imparts knowledge on development of optimization procedures for strain improvement, optimizing metabolic flux by up-regulation of a target pathway and/or knock-out of competing pathways and heterologous expression of foreign gene / gene cluster to introduce metabolites for biosynthesis of target product.

UNIT - 1

METABOLIC CHARACTERIZATION AND MODELS FOR CELLULAR REACTIONS [7 L]

Overview to the field with illustrating examples. Central Metabolism: Fueling metabolism, Supply of biomass precursors, Anabolism, Anaplerosis. Coordination of metabolic reactions: Feedback inhibition, Energy charge, Multigene networks. Methods for metabolic characterization: Genome, Transcriptome, Proteome, Metabolome and Fluxome. Comprehensive models for cellular reactions: Stoichiometry of cellular reactions, Reaction rates, Dynamic mass balance.

UNIT - 2

REGULATION OF METABOLIC PATHWAYS AND METABOLIC FLUX ANALYSIS [9 L]

Regulation of metabolic pathways: Regulation of Enzymatic Activity and Enzyme concentration, Regulation at whole cell level, Regulation of Metabolic networks. Metabolic flux analysis: Overdetermined and undetermined systems, Sensitivity analysis.

UNIT - 3

METHODS FOR METABOLIC FLUX ANALYSIS AND ITS APPLICATIONS

Methods for Metabolic Flux Analysis; Metabolite Balancing, Tracer Experiments, MS and NMR in labelling measurement. Applications of metabolic flux analysis. **[7 L]**

UNIT - 4

METABOLIC CONTROL ANALYSIS AND METABOLIC DESIGN [9 L]

Metabolic control analysis (MCA): Determination of Flux control coefficients, MCA of Linear and Branched pathways. Metabolic design: Gene amplification, Gene disruption, Randomized and targeted strain development.

UNIT - 5

METABOLIC ENGINEERING IN PRACTICE (Case studies) [7 L]

Engineering the isobutanol biosynthetic pathway in *Escherichia coli* by comparison of three aldehyde reductase/alcohol dehydrogenase genes; Compartmentalization of metabolic pathways in yeast mitochondria improves the production of branched-chain alcohols; Metabolic engineering of *Escherichia coli* to increase NADH availability by overexpressing an NAD+-dependent formate dehydrogenase; Engineering *Escherichia coli* for production of functionalized terpenoids using plant P450s; Industrial production of amino acids by coryneform bacteria; Engineering of *Escherichia coli* for fuel production (Microdiesel).

PRIMARY REFERENCES

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998.
2. David Fell, Understanding the Control of Metabolism, Portland Press, London, 1997.

SECONDARY REFERENCES

1. S. Y. Lee & E.T. Papoutsakis, Metabolic Engineering, Marcel Dekker, New York, 1999.
2. R.Heinrich and S. Schuster, The Regulation of Cellular Systems, Chapman & Hall, 1996.
3. E.O. Voit, Computational Analysis of Biochemical Systems. Cambridge University Press, 2000.

e-BOOKS

1. https://books.google.co.in/books/about/Metabolic_Engineering.html?id=9mGzkso4NVQC
2. http://onlinelibrary.wiley.com/doi/10.1016/S0307-4412(97)87557-7/abstract

MOOCs

1. http://www.nptel.ac.in/syllabus/102103014/

COURSE OUTCOMES

1. Elucidate central metabolic reactions and models used for cellular reactions (PO1).
2. Comprehend regulation of metabolic pathways at different levels and analyze metabolic flux for real time applications (PO1, PO2).
3. Describe the metabolic control analysis and plan a suitable metabolic design for maximizing product yield (PO3).
4. Relate applications of metabolic engineering for current research/industrial practices (PO1, PO12).

Course Title	BIOINSTRUMENTATION AND BIOSENSORS										Credits	3			
Course Code	1	6	B	T	6	D	E	B	I	B	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Human Physiology, Engineering Physics, Engineering chemistry, Basic Electrical Engineering and Elements of Electronics Engineering.

COURSE DESCRIPTION: This course deals with the recording of signals and monitoring instruments. The course also includes various types of measuring and analysis techniques used in different areas of healthcare. The course imparts knowledge on various types of biosensors, their design and applications.

COURSE OBJECTIVES: To enable the students to understand the principle, components and applications of biomedical devices related to cardiovascular and respiratory system. To enable the student to use the knowledge in designing a biosensor to apply in healthcare, environment and bioprocess industry.

UNIT - 1

FUNDAMENTALS OF MEDICAL INSTRUMENTATION [9 L]

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

UNIT - 2

CARDIOVASCULAR SYSTEM [7 L]

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

RESPIRATORY SYSTEM [7 L]

Overview of 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 equipment; Anesthesia machines: related instrumentation of equipments involved and sensors, Conceptual numericals.

UNIT - 4

DESIGN OF BIOSENSORS & BIOCHIPS [6 L]

History and overview of Biosensors, components of a biosensor, design considerations, commercial requirements and obstacles in biosensor development; Types of biosensors;

Biochips: Types, design, operating principles and related instruments.

UNIT - 5

APPLICATIONS OF BIOSENSORS [10 L]

Electrochemical sensors, chemical fibro sensors, ion selective FETs, Micro Electromechanical sensors (MEMS). Biosensors for Health: Biosensors for diabetes, cardiovascular diseases, cancer applications. Nanobiosensors : Glucose biosensors, Cholesterol biosensors, Tyrosinase biosensors, Urease biosensors, Acetylcholinesterase biosensors. Biosensors for environmental Applications: detection and quantification of heavy metals, oxygen demand and xenobiotics. Bioindicators, role of biosensors in bioprocess and its challenges;

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

e-BOOKS

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

MOOCs

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

COURSE OUTCOMES

1. Describe components and applications of biomedical devices (PO1, 6).
2. Select and describe usage & working principle of biomedical devices for cardiovascular and respiratory system measurements (PO1, 5, 6).
3. Apply the concepts in design of a biosensor (PO1, 6 &7) to detect analytes .

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

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

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

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

UNIT – 1

EMERGENCE OF NEXT-GENERATION SEQUENCING [9 L]

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

UNIT - 2

THE ASSEMBLY OF SEQUENCING DATA [6 L]

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

UNIT - 3

DE NOVO ASSEMBLY ALGORITHMS [7 L]

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

UNIT - 4

NEXT GENERATION SEQUENCING IN CANCER RESEARCH [10 L]

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

UNIT - 5

NEXT GENERATION SEQUENCING IN CLINICAL RESEARCH [7 L]

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

1. Genomes by Brown T A, 2006, Fifth edition, Garland Science.
2. A Primer of Genome Science by Greg Gibson and Spencer V, Third Edition, Sinavec Associate INC

e-BOOKS

1. http://www.springer.com/us/book/9781461477259

2. http://store.elsevier.com/Challenges-and-Opportunities-of-Next-Generation-Sequencing-for-Biomedical-Research/isbn-9780123942876/
3. http://vufind.carli.illinois.edu/vf-rou/Record/rou_279168/TOC

MOOCs

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

COURSE OUTCOMES

1. Comprehend and compare various Next-Generation Sequencing Techniques (PO1, PO12)
2. Comprehend and apply the tools for assembly of Sequencing Data. (PO1, PO5, PO12)
3. Illustrate applications of different algorithms used to acquire, analyse, assemble and visualize the genomic sequence data. (PO2, PO12)
4. Relate the application of NGS in diagnosis and treatment of diseases. (PO1, PO6)

Course Title	FOOD BIO-TECHNOLOGY										Credits	3			
Course Code	1	6	B	T	6	D	E	F	B	T	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Unit Operations 1, Unit Operations 2, Microbiology, Basics of Biomolecules

COURSE DESCRIPTION: This course includes the characteristics of food, techniques involved in food processing and preservation.

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

UNIT - 1

INTRINSIC AND EXTRINSIC PARAMETERS OF FOODS [7 L]

Colloidal Systems in Food and its Stability, Types of Food Starches, Soluble Fibres (Pectins, Gums, Mucilages), Protein Rich Foods, Popular Fats and Oils in Foods, Factors leading to Rancidity and Reversion, Prevention of rancidity, Minerals in Foods, Aroma Compounds in Foods (monosodium glutamate, nucleotides), Food Flavours, Browning Reactions, Vitamins and Amino Acids in Foods, Sugar substitutes (sorbitol. Sweeteners-saccharin, cyclamate), Food colours, Anti-nutritional factors, Chemical changes during Processing of Compounds.

UNIT - 2

FOOD INDUSTRY AND BIOTECHNOLOGY [8 L]

Objectives and Effect of Food Processing on Food Constituents, Methods of Evaluation of Food, Nutritional value, Labeling of constituents , Food Packaging, Applications of Biotechnology to food industry: Nutraceuticals, Flavonoids, Antioxidants, Utilization of Enzymes (hydrolases, pectinases and lipases) and applications of Immobilized Enzymes in Food Industry, Economic Aspects, Regulatory and Social Aspects of BT.

UNIT - 3

FOOD MICROBIOLOGY [6 L]

Primary Sources of microorganisms found in Foods, Synopsis of Common Food-borne bacteria, Synopsis of Genera of Molds and Yeasts Common to Foods, Microbial Spoilage of Vegetables, Fruits, Fresh and Processed Meats, Poultry, and Seafood, Microbiological Examination of surfaces, Air Sampling, Metabolically Injured Organisms, Enumeration and detection of food-borne organisms.

UNIT - 4

FOOD PRESERVATION [12 L]

Food Preservation using irradiation: Characteristics of Radiations of Interest in Food Preservation, Principles Underlying Food Preservation by Irradiation, Processing of Foods for Irradiation, Effect of Irradiation on Food constituents, Legal Status of Food Irradiation, Properties of Fluid Foods, Solid Foods And Granular Food and Powders, Measurement of Rheological Parameters, Measurement of Food Texture, Thermal Properties of Frozen Foods, Prediction of Freezing Rates: Qualitative Explanation via Plank's Equation, Neumann Problem and Tao Solution, Food Freezing Equipments: Air Blast Freezers, Plate Freezers and Immersion Freezers, Food Dehydration: Estimation of Drying Time, Constant Rate Period and Falling Rate Period Dehydration, Equipments: Fixed Tray Dehydration, Cabinet Drying, Tunnel Drying. Freeze Dehydration, Calculation of Drying Times.

UNIT - 5

PROCESSED FOOD PRODUCTS [6 L]

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

1. Food Microbiology: M.R.Adams and M.O.Moss
2. Introduction to Food Engineering: R. Paul Singh, Dennis R. Heldman, Amsterdam [u.a.]: Elsevier, 2007.

e-BOOKS

1. Applications of Biotechnology in Traditional Fermented Foods. By 'Panel on the Applications of Biotechnology to Traditional Fermented Foods, National Research Council'
2. Food Microbiology (Sie) by Frazier,Tata McGraw-Hill Education, 1987
3. Modern Food Micro-Biology: James M.Jay, (2005), CBS Publishers.

MOOCs

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

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

COURSE OUTCOMES

1. Comprehend the physico-chemical characteristics of foods. (PO1)
2. Apply biotechnological procedures in food industry. (PO1, PO5)
3. Apply various methods for identification of microbes in food. (PO1, PO5)
4. Identify suitable techniques for preservation of food. (PO1, PO5)

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

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

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

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

PART A: THEORY+TUTORIAL

UNIT 1

INTRODUCTION TO BIOPROCESS DESIGN [4L+2T]

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

UNIT 2

BIOPROCESS COMPONENTS [4L+3T]

Welding Joints, pipe fittings, Flanged pipe joint, Gland & Stuffing box expansion joint Ball valve, Gate valve, Non- return valve, Diaphragm valve, Centrifugal pump, Peristaltic pump, Bioreactors, types, Filtration units: Normal flow and tangential flow (TFF) filtration systems

UNIT 3

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

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

PART B: LABORATORY

CAD of

1. Flanged pipe joint
2. Gland & Stuffing box expansion joint
3. Ball valve
4. Gate valve
5. Non- return valve
6. Diaphragm valve
7. Centrifugal pump

8. Peristaltic pump
9. Shell and tube exchangers
10. Fermenter
11. Distillation column-Packed bed
12. Extractor

COURSE OUTCOMES

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

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

E-BOOKS

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

MOOCs

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

Course Title	PROCESS PLANT DESIGN AND ECONOMICS										Credits	3			
Course Code	1	6	B	T	7	D	C	P	P	E	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Knowledge of Unit Operations, Enzyme Kinetics and Reaction Engineering and Process control & automation

COURSE DESCRIPTION: This course intended to demonstrate the importance of economic considerations in the design of process equipment and plant facilities to the students. This course enables the students to apply economic analytical methods to evaluate plant design options, selection of manufacturing process and site to maximize the profitability.

COURSE OBJECTIVES: To demonstrate the importance of economic considerations in the design of process equipment and plant facilities to the students.

UNIT 1

PLANT DESIGN CONCEPTS **[7L]**

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

PROJECT COSTING **[8L]**

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, working capital and its determinants.

UNIT 3

PRODUCTION COST **[7L]**

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

INTEREST AND DEPRECIATION **[10L]**

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, methods for determining depreciation, single unit and group depreciation.

UNIT 5

PROFITABILITY ANALYSIS **[7L]**

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 depreciation charges
4. Select suitable process by estimating the production cost and profitability analysis

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

E-BOOKS

1. http://www.freeengineeringbooks.com/Civil/Engineering-Economics-Books.php
2. Engineering Economics, Second Edition- Kindle Edition
3. http://www.cognella.com/pdf/Fundamentals-of-Engineering-Economics_sneak_preview.pdf

MOOCs

1. http://nptel.ac.in/courses/103103039/40
2. http://www.shortcoursesportal.com/studies/75847/competency-in-chemical-engineering-and-plant-design.html

Course Title	BIOETHICS, BIOSAFETY and IPR										Credits	5			
Course Code	1	6	B	T	7	D	C	B	I	P	L-T-P-S	3	0	0	2

COURSE PRE-REQUISITES: Knowledge of Constitution of India and Professional Ethics, Microbiology, Genetic engineering, Pharmaceutical BT, Animal BT, plant BT

COURSE DESCRIPTION: The course deals with IPR laws and agreements related to biotechnology. The course also includes impact of biotechnology on society, ELSI of biotechnology solutions and biosafety levels.

COURSE OBJECTIVES: On completion of the course, students will have fundamental concepts of IP laws and protection, agreements, ELSI and safety issues governing a technology.

UNIT 1

FUNDAMENTALS OF IP [8L]

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

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

UNIT 2

IPR IN BIOTECHNOLOGY [10L]

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

UNIT 3

ETHICAL ISSUES OF BIOTECHNOLOGY IN SOCIETY [10L]

BT and social responsibility, public acceptance issues in biotechnology: Issues of access, ownership, monopoly, traditional knowledge, biodiversity and environmental sustainability, public vs. private funding, globalization and development divide. Impact of biotechnology across the world, Impact of Bt cotton and acceptance issues of Bt brinjal in India. Ethical complications of BT: Interference with nature, fear of unknown, unequal distribution of Risks and benefits. Medical ethics and issues of modern BT applications in medicine: Basic principles of medical ethics, Stem cell and gene therapy, Synthetic or artificial cell, HGP and its issues

UNIT 4

BIOSAFETY CONCEPTS AND ISSUES [6L]

Definition of Risk and its classification, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. Biosafety levels: Different types and description. Laboratory associated infections and other hazards, Assessment of biological hazards. Biological weapons: - Types and possible role of RDT in production of novel bioweapons. Social, Economic and ethical implications of Bioterrorism.

UNIT 5

BIOSAFETY REGULATIONS AND GUIDELINES [5L]

Biosafety assessment procedures in India and abroad, International dimensions in biosafety: Cartagena protocol on biosafety. CBW. Biosafety regulations (national and international guidelines): Guidelines on rDNA technology, transgenic science, GM crops, Experimental protocol approvals, levels of containment. Guidelines for research in transgenic plants. Biosafety assessment of pharmaceutical products such as drugs/vaccines (products out of RDT),

COURSE OUTCOMES

1. Understand the basic structure of intellectual property and its relevance to modern biotechnology
2. Adoption of patenting system in day-today research for protecting innovative ideas as well as the age-old traditional skills
3. Inculcate ethics and understand the possible societal anticipations of outcomes from potential applications of biotechnology targeting the end-user.
4. Learn and adopt the established guidelines with respect to biosafety practices in research and development sectors

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

PRIMARY REFERENCES

1. **Basic Intellectual property rights**, Paper I, Dr. Ramakrishna, National Law School of India University,
2. **Ownership and enforcement of IPR** by Dr. T. Ramakrishna, NLSIU, Bangalore
3. **Bioethics & Biosafety** by Sateesh MK (2008), IK Publishers.

4. **Biotechnology and Safety Assessment** by Thomas by J.A., Fuch, R.L. (2002), Academic Press.

SECONDARY REFERENCES

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

E-BOOKS

1. https://vufind.carli.illinois.edu/vf-tiu/Record/tiu_576971

MOOCs

1. https://www.mooc-list.com/course/bioethics-law-medicine-and-ethics-reproductive-technologies-and-genetics-edx

Course Title	MINI PROJECT										Credits	4			
Course Code	1	6	B	T	7	D	C	M	P	R	L-T-P-S	0	0	4	0

COURSE OUTCOMES

1. Comprehend a given problem pertaining to BT
2. Compile, analyse and interpret data from the literature collected and derive valid conclusion
3. Design and conduct preliminary experiments independently toward standardization of protocols within a given period of time.
4. Write effective report and Communicate effectively by oral presentation

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

Course Title	BIOTECHNOLOGY FOR SOCIETY										Credits	3			
Course Code	1	6	B	T	7	D	C	B	F	S	L-T-P-S	1	0	0	2

COURSE PRE-REQUISITES: Basic knowledge in biochemistry, cell biology and genetic engineering. Course description:

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

COURSE OBJECTIVES: Upon completion of the course students should be able to understand the impact of biotechnological process and its products on the society. Students should be able to critically analyse and evaluate the issues and ethical considerations while applying bio technological solutions.

UNIT 1 **[13L]**

What Is Biotechnology? The Long History of Biotechnology. Inventing Genetic Engineering, Recombinant DNA, Biotechnology and Business Patenting. Life, Risk, Regulation, and Our Food. Owning Part of You, Freezing, Banking, Crossing, and Eugenics. The Human Genome Project, Genetic Testing, Disability, and Discrimination, Bioethics and Medicine, From the Pill to IVF, Cloning, Stem Cells, Designer Babies, Drugs and Designer Bodies, Personal Genomics, Biotechnology and Race. Bioprospecting and Biocolonialism, Synthetic Biology and Bioterrorism, Biotechnology and Art, Eternal Life and the Post human Future

COURSE OUTCOMES

1. Comprehend the role and impact of Biotechnology on the society .
2. Understand the responsibility of biotechnologist towards society.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1						3	1					
CO2						3	1					

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

Course Title	INDUSTRIAL BIOTECHNOLOGY										Credits	3			
Course Code	1	6	B	T	7	D	E	I	B	T	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Knowledge of Microbiology, Unit Operations-1, Unit operations-2, Biochemistry, Molecular Biology, Genetic Engineering, Bioprocess Technology

COURSE DESCRIPTION: The course deals with bioconversion and media design. It also emphasizes on large scale production of different primary and secondary metabolites.

COURSE OBJECTIVES: On completion of the course, students will have fundamental concepts of process flow diagrams of important products and processes employed in modern biotechnology industry.

UNIT 1

INTRODUCTION [4L]

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

UNIT 2

PRODUCTION OF ORGANIC ACIDS, AMINO ACIDS & ENZYMES [10L]

Organic Acids-Fumaric Acid, Itaconic Acid, Kojic Acid, Bacterial Gluconic and –Ketogulatic with process Flow sheets. Production of amino acids. Enzymes as fermentation Products: Amylases, Proteolytic Enzymes, Pectinases, Invertase.

UNIT 3

PROCESS TECHNOLOGIES FOR SECONDARY METABOLITES [6L]

Production of antibiotics with process flow sheet-penicillin and tetracycline, Production of vaccines.

UNIT 4

PRODUCTION OF ORGANIC SOLVENTS [9L]

Anaerobic Fermentations-Acetone-Butanol Fermentation, Brewing, Industrial Alcohol. 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.

UNIT 5

PRODUCTION OF FOOD PRODUCTS [10L]

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. Understand the concept of bioconversion and media design.
2. Identify and analyze the metabolic pathways involved in production of different metabolites from living organisms.
3. Distinguish and apply the process technologies for large scale production of industrially important products from living organisms.

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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.

E-BOOKS

1. http://www.vitorrentz.co/search/Prescott+and+Dunn%E2%80%99s+Industrial+Microbiology,+4th+E
2. Kirk-Othmer Encyclopedia of Chemical Technology 5th Edition, Vol. 18 (Volume 18)

MOOCs

1. https://www.edx.org/course/industrial-biotechnology-delftx-ib01x-0
2. https://online-learning.tudelft.nl/courses/industrial-biotechnology/

Course Title	AQUA AND MARINE BT										Credits	3			
Course Code	1	6	B	T	7	D	E	A	M	T	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Knowledge of Basic Biology, Cell and molecular Biology, Microbiology, Genetic Engineering, Immunology and Bioprocess Technology.

COURSE DESCRIPTION: This is an exclusive elective offered to students in case they would like to pursue their career in industry and academia dealing with Marine BT. The course provides a details theoretical knowledge in all the areas of marine BT.

COURSE OBJECTIVES: On completion of the elective, students will have a broad understanding in concept and applications of marine BT.

UNIT 1

AQUATIC ENVIRONMENT AND AQUACULTURE [9L]

Major physical and chemical factors (light, temperature, gases, nutrients). Aquatic biota: phytoplankton, zooplankton, benthos, periphyton, macrophytes, fish and other animals. Production & Nutrient dynamics in lakes, rivers, estuaries and wetlands. Eutrophication and water pollution: monitoring and control conservation and management of lakes, rivers and wetlands. Importance of coastal aquaculture - design and construction of aqua farms, Criteria for selecting cultivable species. Culture systems – extensive, semi intensive and intensive culture practices. Classification and Characteristics of Arthropoda. Crustacean characteristic key to Myanmar's Economically Important species of Prawns and Shrimps, General biology, embryology, morphology, anatomy and organ systems of – (a) Shrimp and Prawn, (b) Finfish, (c) Marine and freshwater fish. Preparation, culture and utilization of live food organisms, phytoplankton zooplankton cultures, Biology of brine shrimp Artemia, quality evaluation of Cyst, hatching and utilization, culture and cyst production.

UNIT 2

PUBLIC HEALTH, FOOD HYGIENE & FOOD PROCESSING [9L]

The science of public health will be introduced: basic concepts, infectious diseases, auto-immune diseases, life-mode diseases, marine-related diseases, major food poisoning and indicator organisms of concern to public health, and functional foods. Food-related problems based on sanitation law will be elaborated: natural toxins, hazardous substances (e.g. mycotoxins, heavy metals), food additives, parasites, and food allergy. Fundamentals and techniques of food processing (especially seafood) and food safety will be discussed: purpose and types of processing techniques for marine plant and animal products, preservation techniques, microbiological examining methods, packaging, standardisation of processed foods, product value, labelling and quality control.

UNIT 3

TECHNIQUES [6L]

Chromosome manipulation in aquaculture - hybridization, ploidy induction, gynogenesis, androgenesis and sex reversal in commercially important fishes. Application of microbial

biotechnology in culture ponds, bioaugmentation, bioremediation, nutrient cycling, and bio-fertilization. Probiotics – Immunostimulants. Tools for disease diagnosis in cultivable organisms - Enzyme immuno assays - Dot immunobinding assay - Western blotting - Latex agglutination test - Monoclonal antibodies - DNA based diagnosis. Cryopreservation techniques.

UNIT 4

MARINE BIOTECHNOLOGY **[8L]**

Physical, Chemical and Biological aspects of marine life. Air – Sea interaction – Greenhouse gases (CO2 and Methane). Marine pollution-major pollutants (heavymetal, pesticide, oil, thermal, radioactive, plastics, litter and microbial). Biological indicators and accumulators: Protein as biomarkers, Biosensors and biochips. Biodegradation and Bioremediation. Separation, purification and bioremoval of pollutants. Biofouling - Biofilm formation Antifouling and Anti boring treatments. Corrosion Process and control of marine structures. Biosafety - special characteristics of marine environment that bear on biosafety. Ethical and moral issues -food health, and environmental safety concerns. Biotechnological applications in aquaculture (expression of the eucaryotic gene, genes cloned from fish, introduction of the heterologous gene in fish, gene therapy) and safety evaluations of applications in aquaculture

UNIT 5

MARINE PHARMACOLOGY **[7L]**

Terms and definitions. Medicinal compounds from marine flora and fauna - marine toxins – antiviral, antimicrobial. Extraction of crude drugs, screening, isolation, purification and structural characterization of bioactive compounds. Formulation of drugs and Drug designing: Pharmacological evaluation – routes of drug administration – absorption, distribution, metabolism and excretion of drugs.

COURSE OBJECTIVES

1. Understand the biology of marine micro-macro flora and fauna.
2. Apply the techniques for detection of marine organism and bio-augmentation.
3. Comprehend on the marine food processing, product and safety.
4. Screening & purification of bioactive compounds from marine flora & fauna.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	2											
CO2					3		2					2
CO3						2		1				
CO4					2							

PRIMARY REFERENCES

1. **Recent advances in Marine Biotechnology**. Vol. 4. Fingerman, M.
2. **Marine Biotechnology** by David J.Attaway et al.,

SECONDARY REFERENCES

1. **Aquaculture**, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
2. **Aquatic Microbiology**, Rheinhemer, G., 1980. Johnwiley & Sons, pp. 235.

MOOCs

1. Marine and Antarctic Science (Open2Study), Link: https://www.mooc-list.com/course/marine-and-antarctic-science-open2study?static=true

Course Title	BIOMATERIALS AND TISSUE ENGINEERING										Credits	3			
Course Code	1	6	B	T	7	D	E	B	T	E	L-T-P-S	3	0	0	0

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

COURSE DESCRIPTION: This course deals on functional biomaterials used in drug delivery and therapeutics, artificial implants, organs that are being used.

COURSE OBJECTIVES: The goal of this course is to enable students to understand the biological and physical principles of the biomaterials, to understand how they functions and various applications of biomaterials that under current use.

UNIT 1

CHARACTERIATICS OF BIOMATERIALS [6L]

Introduction to Materials Science: mechanical properties, Strength and ductility, viscoelasticity. Classification of bio-materials (inert, bioactive and biodegradable) organic functional groups needed for biomaterials, Nucleophilic and Electrophilic groups, pKa of important biomolecules, Transition states, and intramolecular reactions. Degradation of biomaterials, Protein adsorption to materials.

UNIT 2

IMPLANT MATERIALS & BIOCOMPATIBILITY [7L]

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

UNIT 3

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

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

UNIT 4

HUMAN TISSUE AND ORGANS [10L]

Introduction to human tissues and tissue development: stem cells; morphology of human tissues and organs: muscle tissue, adipose tissue, connective tissue, nervous tissue and epithelial tissues.

Organs: heart, liver, kidney, pancreas, bone &bone marrow and ECM. Tissue homeostasis and importance of cellular signaling in tissue engineering.

UNIT 5

SCAFFOLDING **[10L]**

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

COURSE OUTCOMES

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

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

E-BOOKS

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

MOOCs

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

Course Title	CLINICAL DATA MANAGEMENT										Credits	3			
Course Code	1	6	B	T	7	D	E	C	D	M	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Pharmaceutical Biotechnology, Biostatistics

COURSE DESCRIPTION: This course emphasizes on clinical trials and data management. It also portraits the role of CRC and CRA in clinical trials for effective data management in clinical research.

COURSE OBJECTIVES: This course is designed to impart good knowledge in principles and practices of clinical research. Further students will inculcate these for clinical trials design, project management, resource management and data handling to develop a quality data management system

UNIT 1

INTRODUCTION **[9L]**

Introduction to Clinical Trials: scope of clinical trial, clinical trials Phases, Phase I studies;Phase II studies; Phase III/IV studies Introduction to ethics of Clinical Trials. Study Population: Definition of study population, Issues on generalization. History of clinical trials, Basic principles, Clinical trial, designing clinical trial: Planning steps (Develop a hypothesis for research, Define the objectives and Establishment, Define the variables needed, Define the study population, finalize the objective into testable hypothesis Predict error and bias, Selection of appropriate study design, Determination of sample size), Execution steps: Data collection process, Data entry and management and Publication.

UNIT 2

DATA REVIEW AND VALIDATION **[8L]**

Point by Point Checks, Missing Data or blank field Checks, Data consistency Checks Laboratory Data and range Checks, Discrete value group dispensary Checks, Header Inconsistency Checks, Missing page Checks and CRF tracking, Protocol validation Checks, continuity Data Checks, coding Checks, external Data Checks, textual DataChecks, SAE Reconciliation Checks. Discrepancy Management (brief), Database closure, Quality assurance, Data storage and archival and recent advances in CDM.

UNIT 3

INFORMED CONSENT PROCESS [6L]

Introduction, the history of informed consent and the system of subject protection, Basic principles; autonomy, beneficence, justice. Informed consent process, preparing the informed consent document, checklist, ensuring readability of the informed sheet and the consent form, special considerations.

UNIT 4

ROLE OF CRC AND CRA IN CLINICAL TRIALS [9L]

The clinical research associate and coordinator, who can be a CRC/CRA, the sites where CRC/CRA works, responsibilities; general responsibilities; capacity building, trial related responsibilities; site identification, pre-trial documentation, IRB, regulatory, financial, administrative, training of the site staff, informed consent forms, site initiation visit, investigators meeting screening and recruitment, scheduling of visit, accountability, laboratory, monitoring. Skills of being a good CRC/CRA; watch, listen, document and report. Documentation of informed consent), plan for administrative support (budget; personnel, equipment, facilities and suppliers, resources and environment, personnel; qualifications, time commitment, job descriptions, consultant

UNIT 5

DATA MANAGEMENT IN CLINICAL RESEARCH AND LITERATURE SURVEY [7L]

Introduction: Overview of Clinical Data Management (CDM), Kinds of Data, Data Management plan, Data capture and collection: Paper CRF based studied based study, Data Privacy. CRF Design: Paper based and electronic based CRF process, CRF login and inventory. Clinical Database. Data entry: double entry, single entry. Library sources; search engines, databases, search strategies, limiting the search using logical operators, broadening the search, sensitivity and specificity of literature searches, finding references for evidence- based practice, review and abstracts for evidence- based practice.

COURSE OUTCOMES

1. Apply principle steps in drug discovery
2. Outline the pertinent issues involved in undertaking of clinical research and recruitment of subjects for study
3. Distinguish the roles of CRC, CRA for effective data management in clinical research.

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

PRIMARY REFERENCES

1. **Basic Principles of Clinical Research and Methodology**. S.K Gupta, 1st edition, Medical Publishers (P) Ltd, 2007.
2. **Foundations of Clinical Research: Applications to Practice**. Leslie Gross Portney, Mary P. Watkins , 3rd edition, Amazon Publications.
3. **Principles and Practices of Clinical Research**. Leslie Gross Portney, Mary P Watkins, Academic Press

SECONDARY REFERENCES

1. **Design and Analysis of Clinical Trials : Concepts and Methodologies-** Shein-Chung Chow, Jen-Pei, Liu Wiley Series in Probability and Statistics.

E-BOOKS

1. http://landingbook.co/practical_guide_for_clinical_data_management.pdf

MOOCs

1. https://www.coursera.org/learn/clinical-data-management
2. https://news.vanderbilt.edu/2013/09/18/coursera-data-management/

Course Title	PROJECT MANAGEMENT AND FINANCE										Credits	3			
Course Code	1	6	B	T	8	H	S	P	M	F	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Process Plant Design and Economics

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

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

UNIT 1

PROJECT IDENTIFICATION & FORMULATION [7L]

Characterization of project, Functional management, Project Life cycle & its phases, defining the project scope, establishing project, project feasibility, Roles and responsibility of project manager, tools and techniques project management, project management objectives.

UNIT 2

PROJECT PLANNING, SCHEDULING & FINANCING [10L]

Work breakdown structure, Bar chart, GAN II chart, developing project schedule: scheduling techniques, terminologies in networking and networking convention: PERT, CPM, procurement schedule, Sources of finance, role of financial institution in project financing, financial analysis of projects.

UNIT 3

PROJECT EXECUTION, CO-ORDINATION & CONTROL [10L]

Communication in a project, Management Information system (MIS), project co-ordination, cost control, crashing of network, controlling project costs: Project cost Vs project completion time, normal time and crash time, time and cost tradeoffs, resource allocation, balance sheet, budget.

UNIT 4

CONTACT AND HUMAN RESOURCE MANAGEMENT [7L]

Types of contracts, sub-contract, tendering procedures, types of payments to contractors, project organization structure project teams, project leadership, project risk management.

UNIT 5

PROJECT PERFORMANCE MEASUREMENT & EVALUATION [5L]

Termination & closeout responsibilities, performance indicators, project evaluation objectives, evaluation methods, post audit: phases & types, audits and audit reports, agencies for post audit.

COURSE OUTCOMES

1. Identify the characteristics of project and role of project manager.
2. Check the feasibility of project and categorize its life cycle
3. Apply scheduling and financing techniques for given project
4. Develop cost control strategies for project
5. Communicate with team and measure the performance of project

Mapping of COs with POs												
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1											3	
CO2											3	
CO3							2				3	
CO4							2				3	
CO5											3	

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

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

E-BOOKS

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

MOOCs

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

Course Title	PROJECT WORK										Credits	10			
Course Code	1	6	B	T	8	D	C	P	R	W	L-T-P-S	0	0	10	0

COURSE OUTCOMES

1. Identify the problem and survey literature pertaining to the problem.
2. Explore for sustainable solutions and reason the impact of BT solutions to the problem chosen.
3. Understand the need for good experimental design and scientific research practices
4. Select an appropriate protocol and conduct the experiments
5. Analyse, interpret data and derive valid conclusions.
6. Write effective report and Communicate scientifically via oral presentation.
7. Execute the project in team within stipulated time period.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	3											2
CO2							2					
CO3			2			2		2				
CO4				3	3							
CO5		3										
CO6										3		
CO7									2		2	

Course Title	INTERNSHIP										Credits	2			
Course Code	1	6	B	T	8	D	C	I	R	S	L-T-P-S	0	0	2	0

COURSE OUTCOMES

1. Survey literature pertaining to given problem
2. Formulate the problem, plan and conduct experiment in a given time period
3. Apply various BT techniques to derive a valid conclusion
4. Write effective report and present effectively by oral communication
5. Ability to work individually or team.

Mapping of COs with POs												
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	3											3
CO2		2	3			2					2	
CO3					3							
CO4										3		
CO5									2			

Course Title	TRANSPORT PHENOMENA										Credits	3			
Course Code	1	6	B	T	8	D	E	T	R	P	L-T-P-S	3	0	0	0

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

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

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

UNIT 1

TRANSPORT PHENOMENA BY MOLECULAR MOTION [7L]

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

UNIT 2

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

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

UNIT 3

EQUATIONS OF CHANGE AND THEIR APPLICATIONS [10L]

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

UNIT 4

TRANSPORT IN TURBULENT AND BOUNDARY LAYER FLOW [7 L]

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

UNIT 5

ANALOGIES BETWEEN TRANSPORT PROCESSES [5L]

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

COURSE OUTCOMES

2. Comprehend one dimensional transport process and its applications in laminar flow and turbulent conditions
6. Identify and Analyze transport process involved in molecular motion.
7. Derive and apply equations for solving momentum, mass and heat transfer problems.

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

PRIMARY REFERENCES

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

SECONDARY REFERENCES

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

E-BOOKS

3. http://www.slideshare.net/Aapandove/bird-stewart-lightfoot-2002-transport-phenomena-2nd-ed
4. https://www.academia.edu/5797564/09_Transport_Phenomena_A_Unified_Approach._Robert_S._Brodkey._Harry_C_Hershey?auto=download

MOOCs

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

Course Title	NANO BIOTECHNOLOGY										Credits	3			
Course Code	1	6	B	T	8	D	E	N	B	T	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Chemistry, Physics, Bioanalytical techniques, Biosensors and Bioinstrumentation, Molecular Biology, Basics of Biomolecules

COURSE DESCRIPTION: This course aims at teaching the fundamentals of nanotechnology and its applications in biomedical and biological research.

COURSE OBJECTIVES: This course will increase the student's competence in using technology applications for control of macromolecules processes.

UNIT 1

INTRODUCTION **[7L]**

A Brief History; Definition of a nano system; Dimensionality and size dependent phenomena: Surface to volume ratio, Fraction of surface atoms, Surface energy and surface stress-, surface defects; Properties at nanoscale (optical, mechanical,electronic,and magnetic).Structure- property relationships in materials. Biomolecule-surface interactions.

UNIT 2

NANOSTRUCURES **[10L]**

Types of nano structures: 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

NANODIAGNOSTICS **[8L]**

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.

UNIT 4

NANO THERAPEUTICS **[8L]**

Drug Discovery Using Nano crystals, Resonance Light Scattering (RLS) and Nano sensors. Benefits of Nano-Imaging Agents, Applications in Drug Delivery - Bioavailability, Sustained and

targeted release, Benefits of Nano-Drug Delivery. Nano robots. Health risks and challenges.

.

UNIT 5

BIOMEMS **[6L]**

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

COURSE OUTCOMES

1. Identify the Nano biomaterials and understand their properties.
2. Apply the concepts of nanotechnology for Nano analytics and characterize nanomaterial.
3. Comprehend the concept of nanotechnology and their role in a wide range of diagnostic and therapeutic applications

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

PRIMARY REFERENCES

1. **A Textbook of Nanoscience and Nanotechnology**, by Pradeep T ,Tata McGraw Hill Education Pvt. Ltd., 2012.
2. **Nanostructured Materials and Nanotechnology** by Hari Singh Nalwa, Academic Press, 2002.
3. **Nanotechnology – Basic Science & Emerging Technologies:** Chapman & Hall/CRC 2002.

SECONDARY REFERENCES

1. **Nanobiotechnology Protocols:** Rosenthal, Sandra J and Wright, David W., Humana Press, 2005.
2. **Nanotechnology:** Richard Booker and Earl Boysen (Eds), Wiley dreamtech 2005 edition
3. **Nanobiotechnology: Concepts, Applications and Perspectives** (2004), Christof M.Niemeyer (Editor), ChadA. Mirkin (Editor), Wiley VCH.
4. **Nanotechnology – A gentle Introduction to the Next Big Idea:** Mark Ratner and Daniel Ratner, Pearson Education, 2005.
4. **Nanobiotechnology - II more concepts and applications**.(2007) **-** Chad A Mirkin and Christof M. Niemeyer (Eds),Wiley VCH.

E-BOOKS

1. https://link.springer.com/book/10.1007%2F978-3-642-02525-9
2. https://link.springer.com/book/10.1007%2F978-1-59745-218-2
3. http://as.wiley.com/WileyCDA/WileyTitle/productCd-3527306587.html

MOOCs

1. https://www.mooc-list.com/tags/nanotechnology
2. https://www.mooc- list.com/course/nanotechnology-and-nanosensors-part-1-coursera

Course Title	DATA ANALYTICS										Credits	3			
Course Code	1	6	B	T	8	D	E	D	A	N	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Basics of computer applications, Bioinformatics, Statistics

COURSE DESCRIPTION: This course emphasizes on need of Data Analytics and its applications to analyse the data. It also portraits the fundamentals of Hadoop, Hive and RHIPE software tool for to analyse the data.

COURSE OBJECTIVES: This course is designed to impart good operational knowledge on basics of Hadoop, Hive and RHADOOP for data analytics. Further students will inculcate these tools and techniques to critically analyse the data.

UNIT 1

INTRODUCTION TO DATA ANALYTICS [8L]

Overview of Data Analytics, Need of Data Analytics, Classification of Data: Structured, Semi-Structured, Unstructured, Characteristics of Data, Big Data Technologies, Big data challenges, Applications of Data Analytics, Modern Data Analytic Tools.

UNIT 2

ONLINE ANALYTICAL PROCESSING (OLAP) [7L]

Introduction, Characteristics of OLAP systems, Multidimensional view and Data cube, Data Cube Implementations, Data Cube operations, Implementation of OLAP and overview on OLAP Softwares.

UNIT 3

HADOOP [7L]

What is Hadoop? Architecture, HDFS: features, Architecture, operations, MapReduce, hadoop ecosystem, Configuration, Uses, Limitations.

UNIT 4

HIVE QL [7L]

Introduction, Data Types and File Formats, Databases in Hive –HiveQL: Data Definition, Data Manipulation, Queries, Views, Indexes, Schema Design

UNIT 5

DATA ANALYSIS USING R AND HADOOP [10L]

Features of R language, R and Hadoop Integrated Programming Environment (RHIPE): Introduction, Architecture, and function reference, RHADOOP: Introduction, Architecture, function reference, SQL on HADOOP.

COURSE OUTCOMES

1. Comprehend the basics of Hadoop, Hive and RHADOOP
2. Apply HADOOP and RHADOOP to analyse the data
3. Design big data applications schema and use HIVE QL to analyse the data.

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

PRIMARY REFERENCES

1. **Hadoop in practice,** ALEX HOLMES. Manning Publications, 2012
2. **Programming Hive**, Edward Capriolo, Dean Wampler, and Jason Rutherglen. O'Reilly Media, First Edition.
3. **Big data analytics with R and Hadoop**. Prajapati, V. Packt Publishing Ltd, 2013
4. **Introduction to Data Mining** by Pang-Ning Tan, Michael Steinbach, Vipin Kumar Pearson Education, 2005.

SECONDARY REFERENCES

1. **An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics.** W. N. Venables, D.M. Smith and the R Development Core Team. Version 3.3.3.
2. **Hadoop: The Definitive Guide** by Tom White Third Edition, O"reilly Media, 2011

E-BOOKS

1. https://www.tutorialspoint.com/hadoop/hadoop_tutorial.pdf
2. http://it-ebooks.info/book/608/

MOOCs

1. https://www.coursera.org/browse/data-science/data-analysis
2. https://www.mooc-list.com/tags/data-analysis

Course Title	ADVANCED PROGRAMMING										Credits	3			
Course Code	1	6	B	T	8	D	E	A	P	G	L-T-P-S	3	0	0	0

COURSE PRE-REQUISITES: Basics of computer applications, Bioinformatics, Genome informatics, Statistics, Genomics and proteomics.

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

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

UNIT 1

R PROGRAMMING BASICS [10L]

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

UNIT 2

INTERFACING [7L]

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

UNIT 3

INTRODUCTION TO BIOCONDUCTOR FOR SEQUENCE DATA [7L]

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

UNIT 4

BIOLOGICAL DATA ANALYSIS [6L]

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

UNIT 5

MASS SPECTROMETRY AND PROTEOMICS DATA ANALYSIS [9L]

Exploring available infrastructure, Mass spectrometry data, Getting data from proteomics repositories, Handling raw MS data, Handling identification data, MS/MS database search, Analysing search results, Analysis of peptide sequences, Trimming the data, Parent ion mass

error, Filtering criteria, Filter optimisation, High-level data interface, Quantitative proteomics, Importing third-party quantitation data, Data processing and analysis, Raw data processing, Processing and normalisation, Statistical analysis, Machine learning: Classification, Clustering: k-means, Annotation.

COURSE OUTCOMES

1. Comprehend the basics of R programming and Bioconductor
2. Apply statistical techniques using R Programming for analysis of data.
3. Analyze and interpret the Biological data using the Bioconductor tools to.

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

PRIMARY REFERENCES

1. **An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics.** W. N. Venables, D.M. Smith and the R Development Core Team. Version3.3.3.
2. **R for Everyone: Advanced Analytics and Graphics:** b y Jared P. Lander Addison-Wesley Data & Analytics Series, 2013.

SECONDARY REFERENCES

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

E-BOOKS

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

MOOCs

1. https://www.class-central.com/tag/r%20programming
2. https://www.edx.org/course/introduction-r-data-science-microsoft-dat2

MANAGEMENT AND ENTREPRENEURSHIP (Proposed)

Subject Code: **HS03**	No. of Credits: 03	No. of lecture hours per week: 03
Exam Duration hours: 03	SEE Marks: 100	Total no. of lecture hours: 39
CIE Marks: 50		

Unit No.	Syllabus Content	No. of Hours
1	**MANAGEMENT:** Introduction-meaning-nature and characteristics of management, scope and functional area of management, management as a science or art of profession, management and administration roles of management, levels of management, Development of management thought -Early management approaches, Modern management approaches.	**08 Hours**
2	**ENTREPRENEUR**: Meaning, evolution of the concept, functions of an Entrepreneur, Characteristics of an Entrepreneur, types of entrepreneur, Intrapreneur – an emerging class. Difference between Entrepreneur, Intrapreneur & Manager, Stages in Entrepreneurial process, Scope of Entrepreneur & Problems of Entrepreneur, Role of Entrepreneurs in economic development, Entrepreneurship-Meaning & Importance of Entrepreneurship in India. Its barriers, Women entrepreneur – Concept & steps to develop Women Entrepreneur.	**10 Hours**
3	**SMALL SCALE INDUSTRY**: Ancillary Industry and Tiny Industry , Definition;, Characteristics; Objectives, Scope and role of SSI in economic Development, Advantages of SSI, problems of SSI, Steps to start an SSI, Government Policy towards SSI; Introduction to GATT/ WTO/ LPG. Forms of ownership. **SUPPORTING AGENCIES OF GOVERNMENT FOR SSI:** Meaning, Nature of support; Objectives, functions. **INSTITUTIONAL SUPPORT:** Different Schemes, TECKSOK, KIADB, KSSIDC, DIC,SISI NSIC, SIDBI, KSFC. Sources of financing an enterprise- long term and short term.	**12 Hours**
4	**PREPARATION OF PROJECT:** Meaning, Project identification, Project selection, Project Report - Need of Project, Contents: formulation:, Net work Analysis Errors of project report, Project Appraisal, Feasibility Study-Market Feasibility Study, Technical Feasibility Study, Financial Feasibility Study, Social Feasibility Study.	**9 Hours**

Note: One question from each Unit of 20 marks each. Questions from Unit 2 and 4 will have internal choice.

RECOMMENDED BOOKS:

1. Entrepreneurship and Management- S Nagendra and V S Manjunath- Pearson Publication 4 /e, 2009.
2. Dynamics of Entrepreneurial Development and Management-Vasant Desai-Himalaya Publishing House.
3. Principles of Management – PC Tripathi, and P N Reddy – Tata MacGraw Hill.

REFERENCE BOOKS:

1. Entrepreneurship Development – Poornima M Charanthimath Pearson Education 2006.
2. Entrepreneurship and management - Shashi k Gupta- Kalyani publishers, Latest edition.

3. Organizational behaviour, Stephen P Robbins, Timothy A. Judge, Neharika Vohra, Pearson, 14/e, 2012.
4. Financial Management- Shashi k Gupta- Kalyani publishers, Latest edition.

COURSE OUTCOMES:

After completing the course, the students will be able to

- Gain knowledge on Management concepts & its evolution.
- Learn the application of Managerial skills & attributes.
- Get an in depth knowledge of Entrepreneurial process & will be able to apply the Entrepreneurial skills.
- Compile information & explore the business opportunities.
- Able to prepare the Business plan.