Semester- II

MOLECULAR BIOLOGY TECHNIQUES			
Course Code	MBBC201	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of the central dogma of molecular biology, including DNA replication, transcription, and translation in both prokaryotes and eukaryotes.
- To equip students with knowledge of various genetic engineering tools, including the use of vectors, enzymes, and techniques for constructing recombinant DNA.
- To develop skills in modern gene transfer and gene editing technologies, including CRISPR-Cas9, and their applications in various biological systems.
- To apply molecular biology principles in the engineering of microbes, plants, and animals for the production of pharmaceuticals, improved crop varieties, and therapeutic interventions.
- To integrate theoretical understanding with practical laboratory techniques in molecular biology, ensuring students are proficient in modern biotechnological applications.

Module-1

CENTRAL DOGMA OF MOLECULAR BIOLOGY - DNA REPLICATION, TRANSCRIPTION, AND TRANSLATION:
DNA replication: Comparative account on initiation, elongation and termination in prokaryotes and eukaryotes. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors. Translation: Genetic Code and Wobble hypothesis, Role of Ribosomes &tRNA; Mechanism of translation: Activation of amino acids, initiation complex formation, elongation of polypeptide, termination and release of polypeptide; Post-translational modifications; Transport of proteins and molecular chaperones.

Module-2

TECHNIQUES IN MOLECULAR BIOLOGY :
Vectors: Cloning & Expression vectors, Plasmids,, Phagemids, Cosmids, YACs and BACs;. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction: General mechanism and applications; Variants of PCR; In vitro mutagenesis

Module-3

TOOLS AND TECHNIQUES IN RECOMBINANT DNA TECHNOLOGY
Vectors: Cloning & Expression vectors, Plasmids,, Phagemids, Cosmids, YACs and BACs;. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction: General mechanism and applications; Variants of PCR; In vitro mutagenesis.

Module-4

GENE TRANSFER and GENE EDITING TECHNIQUES:
Gene transfer into plant cells: Microprojectile bombardment; Agrobacterium transformation, Ti plasmid: structure and functions, Ti plasmid based vectors, Chloroplast transformation; Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Gene transfer techniques into animal/mammalian cells – retrovirus mediated transfection techniques. Gene editing techniques: types, Principles and Applications; CRISPR- associated protein – Cas 9.

Module-5

APPLICATIONS OF GENETIC ENGINEERING:
Engineering microbes to produce antibiotics, enzymes, insulin and monoclonal antibodies. Transgenic technology for plant and animal improvement, Over expression and Knock out/ knock down studies, RNAi. Bio pharming- Animals and plants as bioreactors for recombinant proteins. Gene therapy: Types and case studies of SCID and Cancer gene therapy

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the

credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Molecular Biology of the Cell, 4th edition, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, Garland Science, 2002
2. Molecular Cell Biology, 4th edition, Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell, W. H. Freeman, 2000
3. Genomes, 3rd edition, Brown TA, Garland Science, 2006
4. Gene Cloning: An Introduction, Brown TA, Stanley Thornes Publishers Limited, 1995
5. Molecular Cloning: A Laboratory Manual, Vols 1- 3, J. Sambrook and D.W. Russel, CSHL, 2001

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102103074
2. https://www.youtube.com/watch?v=rEed9iU0WtM
3. https://nptel.ac.in/courses/102106065
4. http://www.digimat.in/nptel/courses/video/102103074/L13.html
5. https://www.youtube.com/watch?v=uZ6pCqCUIco
6. https://archive.nptel.ac.in/courses/104/108/104108056/

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall and describe the processes of DNA replication, transcription, and translation, including the roles of key molecular components.	L1
CO2	Explain the mechanisms and significance of gene transfer, gene editing techniques, and their implications in genetic engineering	L2
CO3	Apply knowledge of genetic engineering techniques to design recombinant DNA constructs using appropriate vectors and enzymes	L3
CO	Analyze the outcomes of gene editing experiments and evaluate the efficiency of different gene transfer methods in various organisms.	L4
CO	Evaluate the potential applications of molecular biology techniques in biotechnology, including the production of therapeutics, crop improvement, and gene therapy.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		2										
CO3			3		2							
CO4				3		2						
CO5							2	2				2

Semester -II

GENOMICS, PROTEOMICS AND BIOINFORMATICS + LAB (IPCC)			
Course Code	**MBBC202**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	4	Exam Hours	3

Course objectives:

- To provide a detailed understanding of genomic and proteomic techniques, including genome sequencing, protein analysis, and bioinformatics tools.
- To develop technical skills in various DNA sequencing methods, including traditional Sanger sequencing, next-generation sequencing (NGS), and their applications in disease diagnosis and research.
- To equip students with knowledge and skills in bioinformatics tools for the analysis of genomic and proteomic data, including sequence alignment, protein structure prediction, and pathway analysis.
- To illustrate the practical applications of genomic and proteomic techniques in research areas such as cancer genomics, drug development, and functional genomics.
- To enhance students' ability to critically analyze complex problems in genomics and proteomics, using modern tools and bioinformatics approaches.

Module-1

INTRODUCTION:

Genome and gene organization, Genomes sequences and data base subscriptions. Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods; Sanger Di-deoxy method, -Maxam &Gilbert Method, Fluorescence method, Shot-gun approach. NGS methods and their principles, Whole Genome Sequencing (WGS) (Illumina, Ion, PacBio, MinION), Whole Exome Sequencing (WES) (Agilent capture kits, IlluminaTruseq, Nextera), Targeted Sequencing, Disease specific panels (Cardiac, Brain, Lung diseases), Cancer panels (all onco panels), and Nutri-genomics panel to identify mutations. Bioinformatics tools and automation in Genome Sequencing, analysis of raw genome sequence data, Transcriptome (RNA) sequencing: Differential gene expression analysis, Understanding the non-coding genome, Disease gene identification.

Module-2

GENOMICS:

General architecture of prokaryotic and eukaryotic genome, coordination of geneexpression, Gene variation and Single Nucleotide Polymorphisms (SNPs), Bioinformatics in detection of Polymorphisms - dbSNP, Gene-disease association, diagnostic genes and drug targets. Genome projects of Model systems: Drosophila, Yeast, C. elegans, E. coli., Arabidopsis and rice; The Human genome project, HapMap Project, The 1000 genome project, and The ENCODE Project. genotyping tools-DNA Chips Interference RNA, RNA silencing, SiRNA. Molecular markers - RFLP, RAPD, AFLP, Micro-array in functional genomics. Human-Microbial Genomics, Metagenomics, Comparative Microbial Genomics: From Sequence to Significance, Infectious Diseases, Emerging Infectious Diseases, Microbial gut flora, Gut-Brain axis. Cancer Genome: Identifying driver and passenger gene mutations using CRAVAT and other tools, identifying translocations (balanced and unbalanced) and inversions, Identifying enhancer elements near translocations and inversions.

Module-3

PROTEOME:

Two-dimensional PAGE for proteome analysis, Detection of proteins on SDS gels, Protein cleavage, Edman protein micro sequencing,Automation in proteomics, Protein- protein interaction assays - Two-hybrid methods, Protein characterization by Mass spectrometry – fundamentals, mass spectrometry ionization techniques, mass analyzers – MALDI-TOF, MS-MS, LC-MS-MS; In-gel digestion, peptide mass fragmentation. Mass-spectrometry data: basics, spectra; Sequence data: databases, tools and resources; Mass-spectrometry search engines, Mass spectra analysis – identification, molecular weight, determination of peptide sequence, determination of post-translational modifications, Peptide Mass finger printing and Post Translational Modifications Interactomics, Protein Arrays and "Protein Chip" - interactions and detection techniques. Human Protein Atlas, Human Proteome Map, Protein

NETWORKS:

String and GeneMANIA Proteome: Co-expression, Co-localization, Physical Interactions, Genetic Interactions, Pathways and Shared Protein Domains of proteins. Proteomics workflows; Proteomics and the study

of diseases, Applications of proteome analysis to drug development and toxicology. Organellar proteomics. Protein Engineering.
Module-4
BIOINFORMATICS RESOURCES: NCBI, EBI, ExPASy, RCSB. Significance of databases towards informatics projects. Databases and classifications. GenBank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, TrEMBL. Gene bank flat file. Protein Data Bank (PDB) flat file; FASTA Format, PIR Format; Structure file formats. the Modular Nature of proteins, Optional Alignment Methods, substitution matrices, Statistical significance of Alignments, BLAST and its different types, Progressive Alignment Methods, MUSCLE, Motifs and Patterns, PROSITE, Hidden Markov Models (HMMs). Phylogenetic analysis: Alignment, Tree Building, and Tree Evaluation, Tree - Building Methods- Distance based and character-based methods, Evaluating Trees and Data- Bootstrapping (parametric and nonparametric), Phylogenetic softwares (CLUSTAL-omega, PHYLIP etc.) NGS Data retrieval: SRA Databases, ENA Data bases, DRA Search, Sequence Quality control, trimming, error correction. Biological pathways: Ingenuity Pathway Analysis, Elsevier Pathway Studio, Biocyc, KEGG, WikiPathways, Pathway Commons, and networks based pathway builder.
Module-5
INSILICO APPLICATIONS: Detecting Functional Sites in the Prokaryotic and Eukaryotic Genomes (promoters, transcription factor binding sites, translation initiation sites), Integrated Gene Parsing, finding RNA Genes, Web based tools (GENSCAN, GRAIL, GENEFINDER). Protein Identity based on composition, Physical properties Based on sequence, secondary structure and folding classes, tertiary structure. protein fold prediction tools, Related web- based software(JPRED,NNPREDICT,SOPMA,DSSP,STRIDE).Restriction mapping, Utilities, DNA strider, MacVector and OMIGA, Web based tools (MAP, REBASE); Primer design–need for tools, Primer design programs and software(PRIME3).3D Structure Modelling in drug discovery, molecular docking, quantitative structure activity relationship(QSAR), deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Ligand-Receptor Interactions: Docking software (AUTODOCK,HEX), Energy Calculations (no derivation).

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Sequence retrieval from Nucleic acid and Protein databases.
2	Sequence (FASTA and BLAST) searches – Retrieval of Homologs, Paralogs, Orthologs, and Xenologs.
3	Pair wise comparison of sequences – Analysis of parameters affecting alignment.
4	Multiple alignments of sequences and pattern determination using PROSITE
5	Processing. fastq/.bam/.vcf files in several genome aligning programs to perform genome alignment using
6	NGS PROGRAMS: StrandNGS, SVS Golden Helix, Genome Browser, CLC Genomics Workbench, and NCBI Workbench.
7	Genome-wide Hot-spot detection using HD-CNV and Circos plot generation.
8	Expression and Enrichment analysis: GenespringGX, Affymetrix Transcriptome Analysis Console,
9	WebGestalt, EnrichR, Gorrila, and DAVID.
10	Protein Interaction Network Programs: Cytoscape-GeneMANIA, Ingenuity Pathway Analysis (IPA), Pathway Studio, KEGG and Wikipathways, and Pathway Commons.

11	Protein Interaction Network Programs: Cytoscape-GeneMANIA, Ingenuity Pathway Analysis (IPA), Pathway Studio, KEGG and Wikipathways, and Pathway Commons.
12	Comparative Modeling of homologous sequences and validation of modeled structures.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test at the end /after completion of all the experiments shall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included. The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

Suggested Learning Resources:

Books

1. Genomics and Proteomics Principles, Technologies, and Applications. By Devarajan Thangadurai and Jeyabalan Sangeetha. Apple Academic Press.2021.
2. Concepts and Techniques in Genomics and Proteomics, by N Saraswathy, P Ramalingam. Woodhead Publishing Series in Biomedicine, 2011.
3. Introduction to Proteomics by D.C Liebler; Humana Press, 2002.
4. Introduction to Genomics Arthur M Lesk, Oxford University Press, 2007
5. Discovering Genomics, Proteomics & Bioinformatics, by A M Campbell & L J Heyer, Pearson Education, 2007
6. Proteins and Proteomics by Richard J Simpson, IK International, 2003.
7. Genomics & Proteomics by Sabesan Ane Books, 2007.
8. Purifying Proteins for Proteomics by Richard J Simpson IK International, 2004.
9. BIOINFORMATICS by Andreas D Baxevanis. Wiley Interscience. 2020.
10. BIOINFORMATICS: by David W Mount, cold spring harbor. 8. Introduction to Bioinformatics by Arthur Lesk, III edition, Oxford Publications. 2004,
11. Structural Bioinformatics by Philip E Bourne, John Wiley & Sons. 2009.
12. Fundamental Concepts of Bioinformatics by D E Krane & M L Raymer, Pearson, 2002.
13. Introduction to Bioinormatics by Arthur Lesk, Oxford University Press, 2014.

Web links and Video Lectures (e-Resources):

1. https://www.coursera.org/courses?query=bioinformatics
2. https://www.edx.org/learn/bioinformatics
3. https://bioinfotraining.bio.cam.ac.uk/
4. https://onlinecourses.nptel.ac.in/noc19_bt25/preview
5. https://pll.harvard.edu/course/introduction-proteomics?delta=0
6. https://www.coursera.org/courses?query=genomics
7. https://www.classcentral.com/subject/genomics
8. https://online.stanford.edu/programs/genetics-and-genomics-program
9. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and describe the basic concepts and methodologies of genomics, proteomics, and bioinformatics.	BTL 1
CO2	Apply DNA sequencing techniques, protein analysis methods, and bioinformatics tools to solve specific problems in genomics and proteomics.	BTL 2
CO3	Analyze and interpret genomic and proteomic data using bioinformatics tools and databases to draw meaningful conclusions.	BTL 3
CO4	Design and optimize bioinformatics workflows for the analysis of large-scale genomic and proteomic datasets, considering public health, safety, and environmental impacts.	BTL 4
CO5	Solve complex problems in genomics and proteomics by integrating knowledge from various techniques and applying modern bioinformatics tools.	BTL 5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problemsand design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	PO10
9	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	PO11
10	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	2					1					
CO2	3	2			2							
CO3		3		2			2					
CO4			3								2	2
CO5				3	2					2		

Semester- II

BIOSEPARATION AND PRODUCT RECOVERY			
Course Code	MBBC203	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of the principles underlying bioseparation processes, including the importance of downstream processing in biotechnology.
- To develop technical skills in the application of various bioseparation techniques, such as centrifugation, filtration, membrane processes, and chromatography.
- To equip students with the knowledge required to design, scale-up, and optimize bioseparation processes for industrial applications.
- To illustrate the practical application of bioseparation processes through real-world case studies in pharmaceuticals, food, and environmental biotechnology.
- To enhance students' ability to analyze, troubleshoot, and optimize bioseparation processes, considering economic and environmental factors.

Module-1

INTRODUCTION TO BIOSEPARATION PROCESSES

Role and importance of downstream processing in biotechnological processes, Overview of bioseparation and its significance in biotechnology-Classification of bioseparation techniques-Principles of bioseparation-Properties of biological materials (size, charge, solubility, and other physical properties)-Basic concepts of process design and scale-up . Problems and requirements of bio product purification. Economics of downstream processing in biotechnology; cost cutting strategies, characteristics of biological mixtures, process design criteria for various classes of by-products (high volume, low valve products and low volume, high valve products).

Module-2

CENTRIFUGATION AND PRECIPITATION

Principles of centrifugation (sedimentation, differential, density gradient)-Types of centrifuges and their applications-Principles and methods of precipitation (salt, solvent, pH-induced)-Factors affecting precipitation efficiency-Scale-up considerations and industrial applications.

Module-3

FILTRATION AND MEMBRANE PROCESSES

Cell disruption methods for intracellular products, removal of insoluble (particulate debris),Principles of filtration (microfiltration, ultrafiltration, nanofiltration, reverse osmosis)-Membrane materials and configurations Membrane based separations (dialysis, micro and ultra-filtration, reverse osmosis), theory design and configuration of membrane separation equipment application. -Membrane fouling and cleaning-Design and operation of filtration systems- Enrichment operations; precipitation methods (with salts, organic solvents and polymer extractive separations aqueous two phase extraction). Discussion of case studies.

Module-4

CHROMATOGRAPHIC TECHNIQUES

Introduction To Molecular Interaction And Chromatography: Adsorption and absorption, Kinds of adsorption interactions. Adsorption characteristics, molecular orientation, adsorption isotherms: quantitative Relationships; adsorption from solutions, and the importance of Adsorption phenomena. Principle and classification of 21 chromatography, important terms of chromatography, Partition chromatography – Single dimensional (Both Ascending and Descending) and 2-D chromatography; Paper chromatography, Thin layer chromatography, Adsorption Chromatography. Optimization of chromatographic separations Scale-up of chromatographic processes -Case studies in pharmaceutical and biochemical industries.

Module-5

ADVANCED BIOSEPARATION TECHNIQUES AND CASE STUDIES

Ion Exchange Chromatography, Ge Filtration Chromatography, Affinity Chromatography. Principle of HPLC, theory and calculations, Instrumentation both analytical and preparative, Types of Columns, Detectors; Sampling Methods; Applications of HPLC, LCMS, GCMS. FPLC, HPTLC. Drying techniques, Crystallization, lyophilisation, Pervaporation, super liquid extraction, foam based separations, in situ product removal, Single step purification, Super critical extraction, online membrane separation, Discussion of case studies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Downstream Process Technology – A new horizon in Biotechnology, Nooralabetta Krishna Prasad, PHI Learning Private Limited, 2010
2. Bioseparation Engineering Endo, T.Nagamune, S. Katoh, T. Yonemoto Japan Nikko 1999
3. Handbook on Bioseparation (separation science and technology) Satinder Ahuja Academic Press 2000
4. Product Recovery in Bioprocess Technology BIOTOL Butterworth Heinemann, 1992

Web links and Video Lectures (e-Resources):

1. http://www.digimat.in/nptel/courses/video/102106022/L01.html

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and describe the key principles and techniques of bioseparation processes.	L1
CO2	Apply the principles of centrifugation, filtration, and chromatography in solving specific bioseparation problems.	L2
CO3	Analyze the performance of different bioseparation techniques and evaluate their efficiency and scalability for industrial applications.	L3
CO4	Design and optimize bioseparation processes for specific industrial applications, considering economic and environmental constraints.	L4
CO5	Solve complex problems in bioseparation processes by integrating knowledge from various techniques and applying modern tools.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	PO10
9	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	PO11
10	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	2					1					
CO2	3		2		2							
CO3			3								2	2
CO4				3	3	2						
CO5				3	3					2		

Semester- I

BIOPROCESS CONTROL AND AUTOMATION			
Course Code	MBBC214A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide students with a thorough understanding of the principles and criteria for selecting measurement instruments for flow, pressure, temperature, and liquid level in biochemical processes.
- To enable students to understand and analyze the dynamic behavior of first-order systems and their responses to various input changes using Laplace transforms.
- To equip students with the knowledge to analyze second-order systems, including interacting and non-interacting systems, and understand their dynamic responses under different conditions.
- To familiarize students with various types of controllers and control elements, including their transfer functions, and enable them to design appropriate control systems for biochemical processes.
- To provide students with the tools and techniques necessary for designing stable control systems, including the application of stability criteria like Routh test, Root locus, and frequency response methods.

Module-1

INSTRUMENTATION:
Principles, Introduction to flow, pressure, temperature and liquid level measurements criteria of selection of measuring instruments, Static characteristics of instruments, Flow injection analysis for measurement of substrates, products and other metabolites, Dynamics and control of bioreactors & sterilizers, On-line data analysis for state and parameter estimation techniques for
biochemical processes

Module-2

FIRST ORDER SYSTEMS:
Process characteristics, Laplace transforms basics, Laplace transform of various forcing functions, first order systems –examples, mercury in glass thermometer, liquid level system, Mixing process, CSTR with first and second order reaction, linearization of first order system, response of first order system for Step, Impulse, Linear and Sinusoidal changes in input, conceptual numericals.

Module-3

SECOND ORDER SYSTEMS:
Dynamics of multicapcity systems (Interacting and Non-Interacting systems-Transfer functions for equal and unequal time constants), and their dynamic response to step and Impulse, inputs, Second order systems with transfer functions (spring -damper), response of second order system to step and impulse for Over damped, underdamped and critically damped conditions, Various terms used to describe underdamped system, Transfer function for transport lag and first order system with transport lag.

Module-4

CONTROLLERS AND FINAL CONTROL ELEMENTS :
Actuators, Positioners, Valve body, Valve plugs characteristics and its types and operating condition (air to close and air to open)and transfer function of final control element (Pneumatic valve), 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, Transfer function for first order process controlled by PI controller, Modes of advance Control techniques (Feed forward, Feed back, Ratio and Adaptive control) conceptual numericals

Module-5

CONTROLLER DESIGN AND STABILITY :
Criteria for stability, Routh test; Root locus (basics), Introduction to frequency response, Qualitative discussion about Bode criteriaand Nyquist criteria; Conceptual numericals

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**

2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Process System analysis and Control by Donald R Coughanowr, McGraw-Hill, 2013.
2. Chemical Process Control by George Stephanopoulos, Prentice-Hall of India, 1982.
3. Bioprocess Engineering Principles by Pauline M. Doran, Academic Press, 2011.
4. Biochemical Engineering Fundamentals by Bailey and Ollis, Mcgraw Hill, 2nd Edition, 2001.
5. Essentials of Process Control by Luyben and Luyben, McGraw-Hill Education, 2005.

Web links and Video Lectures (e-Resources):

1. https://www.coursera.org/lecture/industrial-biotech/microbial-fermentation- processes-and-bioreactor-design-35cbb\VTUEDUSAT / SWAYAM / NPTEL / MOOCS /Coursera / MIT-open learning resource
2. https://www.btec.ncsu.edu/industry/short_courses/fundamentals.php
3. https://www.cytivalifesciences.com/en/us/solutions/bioprocessing/services/training-and-education
4. https://educolifesciences.com/upstream-bioprocess-training

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and explain the principles and selection criteria of measuring instruments for flow, pressure, temperature, and liquid level in biochemical processes.	L1
CO2	Understand and apply Laplace transforms to analyze the dynamic behavior of first-order systems in response to various inputs.	L2
CO3	Analyze the dynamic responses of second-order systems, including the effects of damping and transport lag, using transfer functions.	L3
CO4	Design and evaluate control systems using various controllers (P, PI, PD, PID) and advanced control techniques (Feedforward, Feedback, Ratio, and Adaptive control).	L4
CO5	Apply stability criteria and design stable control systems for biochemical processes, using tools like Routh test, Root locus, and Bode/Nyquist criteria	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	PO11

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	1				1							
CO2		2			2							
CO3		3		3	3							
CO4			3	3	3							
CO5			3	3							3	

Semester- II

BIOSENSORS TECHNOLOGIES			
Course Code	MBBC214B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of the basic components and characteristics of biosensors, including measurement systems, calibration, and sensor integration.
- To impart knowledge on various types of transducers, their principles, and applications in biosensor design, with a focus on modern techniques such as quantum dots and fluorescence enhancement.
- To delve into the biochemical recognition processes, including enzyme kinetics, signal transduction, and the use of nucleic acids, antibodies, and aptamers in biosensor development.
- To explore modern integrated biosensor technologies, such as bioelectronic, biophotonic, and biomechanical sensors, and their applications in lab-on-a-chip devices and nanotechnology.
- To understand the practical applications of biosensors in clinical chemistry, healthcare, agriculture, environmental monitoring, and industrial processes, with a focus on low-cost and mobile biosensors.

Module-1

BIOSENSOR CHARACTERISTICS

Definition and components of biosensor, Basic measurement system, Measurement, Measurand, Errors in Measurements, Signal and Noise, Calibration, Method validation, Surface chemistry, Mass transport, Static characteristics-accuracy, precision, linearity, hysteresis, threshold; dynamic range, Dynamic Characteristics – response time, damping, calibration, standards and AC/DC bridges, Biocompatibility and surface fouling, sensor integration and systems fabrication

Module-2

TRANSDUCERS

Various types of transducers; principles and applications - Calorimetric, Optical, Potentiometric/Amperometric, Conductometric / Resistometric, Piezoelectric, Semiconductor, Impedimetric, Chemiluminescence - based Biosensors, Quantum dots, Fluorescence, Raman Spectroscopy and Fluorescence Enhancement and DNA microarrays

Module-3

BIOCHEMICAL RECOGNITION

Chemical reactions: history of gravimetric and colorimetric reactions. Problems of specificity. Enzymes: biological catalysts, specificity, activity, storage/shelf life. Enzyme kinetics in solution and on a surface. Chemical equilibria-forcing an unfavourable reaction Cells: Signal transduction through chemoreception, membrane potential, cell metabolism, cytotoxicity, and transformed 'bio reporter' organisms. Antibodies: Immunochemistry, binding affinity and kinetics; hapten synthesis. Nucleic Acids (RNA and DNA): Basic biochemistry, hybridization; Amplification/self-replication; Secondary Structure and folding Aptamer (oligonucleotide) based recognition and molecularly imprinted polymers. Common assaying formats, Labels: Radioisotopes, fluorophores, dyes, enzymes/substrates, liposomes, electroactive compounds. ELISAs and nucleotide capture assays.

Module-4

MODERN INTEGRATED BIOSENSORS

Bioelectronic sensors (Fundamentals of microelectronics and CMOS based sensors) Biophotonic sensors (Fundamentals of photonic sensors, Resonant optical sensors, Plasmonic sensors) Biomechanical sensors (Principles of micro-electromechanical (MEM) resonators and sensors) Microfluidic devices for Lab-on-a-chip (Fabrication, Devices and techniques) Application of nanotechnology in biosensing (Nanoparticles, Active nanochannels, Nanoelectronic, Nanophotonic and Nanomechanical sensors) Potential advantages & Developments towards a biomolecular computer, development of molecular arrays as memory stores; molecular wires and switches; mechanisms of unit assembly, Assembly of photonic biomolecular memory store; Information processing; commercial prospects for biomolecular computing systems Chemometrics, Biosensor arrays; Electronic nose and electronic tongue.

Module-5

APPLICATIONS

Biosensor applications in clinical chemistry, medicine and health care, biosensors for veterinary, agriculture and food, Low cost - biosensor for industrial processes for online monitoring; biosensors for environmental monitoring. Application of enzymes in analysis; design of enzyme electrodes and their application as biosensors in industry, healthcare, food and environment, Mobile/Point of Care biosensors

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Chemical Sensors and Biosensors: Fundamentals and Applications", F.-G. Bănică, Wiley, 2012
2. Advances in Biosensors by B.D. Malhotra, A.P.F.Turner, Elsevier JAI, 2003Reference Books
3. Electronic Measurements and Instrumentation, P.Sharma, Umesh Publications, 2006
4. Bioelectronics: From Theory to Applications, I.Willner, E.Katz, Wiley-VCH Verlag GmbH & C0, KGaA, ISBN: 3527306900, 2005
5. Biosensors for environmental monitoring, Bilitewski, U.Turner, A.P.F. Harwood, Amsterdam. 2000

Web links and Video Lectures (e-Resources):

1. https://www.edx.org/course/principles-of-electronic-biosensors
2. https://www.mooc-list.com/tags/biosensors
3. https://www.futurelearn.com/info/courses/music-moves/0/steps/12721
4. https://onlinecourses.nptel.ac.in/noc22_ph01/preview
5. https://archive.nptel.ac.in/courses/127/105/127105225/
6. https://www.biologydiscussion.com/enzymes/biosensors/biosensors-features-principle-and-types-withdiagram/10240

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the basic components and characteristics of biosensors, including measurement systems, errors, and calibration techniques.	L1
CO2	Explain the principles and applications of various transducers used in biosensors, including optical, potentiometric, and piezoelectric transducers.	L2
CO3	Apply knowledge of biochemical recognition processes, including enzyme kinetics, signal transduction, and the use of nucleic acids, to the design of biosensors.	L3
CO4	Analyze modern integrated biosensor systems, such as bioelectronic, biophotonic, and biomechanical sensors, and their applications in lab-on-a-chip devices.	L4
CO5	Evaluate the effectiveness of biosensors in various applications, including clinical chemistry, environmental monitoring, and industrial processes, considering factors like cost and mobility.	L5

Program Outcome of this course

Sl. No	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problemsand design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
7	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	PO11
8	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											2
CO2	3				2							
CO3		3	3	2								
CO4				3	3		2					
CO5			3				3				2	

Semester- II

ENVIRONMENTAL BIOTECHNOLOGY			
Course Code	MBBC214C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of different types of environmental pollution (water, soil, air, noise, and thermal) and their sources, as well as the ecological effects of pollutants on living and non-living systems.
- To impart knowledge on the estimation of BOD, COD, TOC, and waste characterization, along with effective waste management strategies in various industries.
- To explore the various biological and chemical waste treatment methods, including bioremediation, anaerobic and aerobic digestion, and hazardous waste management.
- To understand and apply environmental sensing techniques for the characterization and measurement of water contaminants using advanced spectroscopic and electroanalytical methods.
- To emphasize the importance of environmental policies, regulations, sustainable development, and environmental impact assessments (EIA) in managing and mitigating environmental risks.

Module-1

INTRODUCTION TO ENVIRONMENT:
Concerns pertaining to Ecological damage, Environmental Pollution Types - Water, Soil, Air, Noise and Thermal pollutions, their sources and ecological effects of pollutants on living and non-living systems. Acid rain: sources and solutions. Significance of GHGs and carbon footprint; Biodegradation, of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. Microbial desulfurization of coal. Environmental implications of Acid mine drainage and its remediation; Role of Biotechnology in providing solutions to environmental problems.

Module-2

BOD, COD and TOC
Estimation and correlation; Definition of Waste; Physical, Chemical and Biological characteristics of Industrial waste. Nitrification and Denitrification and their kinetics; Wastewater treatment systems. Waste Management in different industries (food processing, leather tanning, pharmaceutical, textile) Solid waste management: landfills, composting, earthworm treatment, recycling and processing of organic residues, Sources and dispersion of atmospheric pollutants and dispersion models. Control methods for air pollutants, noxious pollutants and odor control; Design of air pollution control equipments; Photochemical reactions.

Module-3

WASTE TREATMENT METHODS:
Types (Suspended and Attached growth processes), Aerobic and Anaerobic treatment of wastes; Other biological treatment process, Anaerobic digestion – Stoichiometry & Kinetic relationships, design consideration, Process modeling and control, Biological nutrient removal, Biological treatments with Case studies; Bioremediation types and biorestoration of contaminated lands. Handling of hazardous wastes from bioprocess industries and related case studies.

Module-4

ENVIRONMENTAL SENSING TECHNIQUES:
Characterization of water contaminants and their measurement Spectroscopic techniques, AAS, NAA, GCMS, HPLC, Electro analytical techniques, Environmental sensing techniques. Discussions with Case studies.

Module-5

ENVIRONMENTAL POLICIES AND REGULATIONS:
Waste minimization and its plan; Conservation of water and energy, Fugitive loss, Programs of municipal pollution control, Risk evaluation and decision analysis. Sustainable development, Environmental Management Systems, ISO and ISO 14000 series: Introduction, Areas covered in the series of standards, Necessity of ISO certification, Environmental Auditing; Other tools for environmental management, Environmental Impact assessment(EIA) and its future and scope. Objectives, Elements of EIA, Baseline studies Methodologies of EIA , Types of impacts, Prediction of impacts and its methodology, Uncertainties in EIA, Status of EIAs in India. EIA at various industries

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The

minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Textbook of Environmental Biotechnology, Pradipta Kumar Mohapatra, I K International, 2007.
2. Hazardous Waste Management, Buckingham and Evans, McGraw Hill International Edition, 2001
3. Biochemical Engineering Fundamentals, Bailey & Ollis, McGraw Hill International Edition, 1986.
4. Standard Methods for the Examination of Water and Waste Water, Laura Bridgewater, American Public Health Association,2007.
5. Environmental Management, N K Uberoi, Excel Books publication, 2007.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/12710 018
2. https://nptel.ac.in/courses/103107212
3. https://nptel.ac.in/courses/105107207
4. https://onlinecourses.nptel.ac.in/noc22_ch33/preview https://nptel.ac.in/courses/129/106/129106002/
5. https://nptel.ac.in/courses/109107171
6. https://onlinecourses.swayam2.ac.in/cec20_ge12/preview

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the different types of environmental pollution and their sources, as well as the basic concepts of acid rain, GHGs, and carbon footprint.	L1
CO2	Explain the significance of BOD, COD, TOC, and the physical, chemical, and biological characteristics of industrial waste, along with waste management techniques.	L2
CO3	Apply various waste treatment methods and bioremediation techniques to effectively manage and treat industrial and hazardous waste.	L3
CO4	Analyze environmental sensing techniques and their applications in detecting and measuring contaminants in water and air, with a focus on case studies.	L4
CO5	Evaluate environmental policies, regulations, and the impact of environmental management systems (EMS) and EIA on sustainable development and risk management.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					2
CO2	3	2					2					
CO3			3	2			2					
CO4		3		2	2							
CO5						3	3	2				

Semester- II

FOOD BIOTECHNOLOGY			
Course Code	MBBC214D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide an in-depth understanding of the basic constituents of food, including colloidal systems, starches, proteins, and oils, as well as the microbiology of food and mechanisms of food spoilage.
- To impart knowledge on various food preservation technologies, including high-temperature processing, dehydration, freezing, and the use of chemicals and bacteriocins.
- To explore the impact of food processing on food constituents, the production of fermented food products, and the role of biotechnology in enhancing food processing.
- To understand the applications of biotechnology in improving food processing, including the use of enzymes, genetically modified plants, and the maintenance of nutritional quality.
- To emphasize the importance of quality assurance and control in the food industry, covering methods of quality assessment, microbiological and chemical safety, and adherence to food regulations and standards.

Module-1

BASIC CONSTITUTES OF FOOD:
Basic constituents of food, colloidal systems in food, molecular stability of colloidal systems, types of food starches, soluble fibers: pectin's, mucilage & gums, protein rich foods, oils in foods. Food Microbiology: Microbial growth pattern, types of microorganisms associated with food: mold, yeast and bacteria. Contaminants of food stuff, milk and meat during handling and processing. Mechanism of food spoilage. Biochemical changes caused by microorganism. Determination of various types of food products. Food borne intoxicants and mycotoxins.

Module-2

FOOD PRESERVATION TECHNOLOGY:
Food preservation by high and ultrahigh temperatures- canning, drying. Food dehydration: Equipments for food dehydration: fixed tray dehydration, cabinet drying, tunnel drying. Freeze dehydration, controlled atmosphere, storage, Food preservation by irradiation treatment. Preservation by freezing and refrigeration. Frozen foods. Thermal properties of frozen foods. Food freezing equipments: Air blast freezers, plate freezers and immersion freezers. Preservation by Chemicals and Bacteriocins.

Module-3

FOOD PROCESSING AND FERMENTED FOOD PRODUCTS
Food Production Technology: Importance of food industry, specific objectives of food processing, impact of food processing on food constituents. Production of single cell protein, Tailoring of milk proteins and milk fats, Production of fermented food products: yoghurt, probiotic cheese, Wine, distilled liquors, Nutritional value, labelling of constituents: Soya foods, organic foods, dietary foods, nutritional food supplements, Use of plant cell culture for the production of food additives (Vanillin, Capsaicin),microbial transformations, regulatory and social aspects of BT. Food packaging, edible films, Marketing of food and promotional strategies.

Module-4

BIOTECHNOLOGY FOR IMPROVED PROCESSING:
Role of biotechnology in food industry, maintenance of nutritional quality, Enzymes in bakery and cereal products, utilization of hydrolases and lipases enzymes. Applications of immobilized enzymes in food industry, enzymes for enhanced flavor and aroma compounds, enzymes in fat and oil industries. Genetically modified plants for high nutritional food.

Module-5

FOOD QUALITY ASSURANCE AND CONTROL:
Importance and functions of quality assurance and control. Methods of quality, concept of rheology, assessment of food materials- fruits, vegetables, cereals, dairy products, meat and processed food products. Microbiological safety of food products, chemical safety of food products, contaminants by heavy metal, fungal toxins and pesticide residue. Food regulations, grades and standards, USFDA/ ISO 9000 Series. Food adulterations and safety, sensors and instrumental analysis in quality control food laws and Standards.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the

credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Food Biotechnology, James M, Jay, CBS Publishers, 2005
2. Food Biotechnology, Kalidas Shetty, CRC Press, ,2005
3. Applied dairy microbiology, H. Elmer, L James, Marath and Steele, CRC Press, 2005
4. Introduction to Food Engineering, R. Paul Singh, Academic Press, 2004
5. Food Processing Technology: Principles and Practice, P. Fellows, Woodhead Publishing Ltd., Cambridge, 2005

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/126/105/126105015/
2. https://onlinecourses.swayam2.ac.in/cec19_ag01/preview
3. https://nptel.ac.in/courses/102106080
4. https://nptel.ac.in/courses/126105015
5. https://onlinecourses.swayam2.ac.in/cec20_ag06/preview

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the basic constituents of food and the principles of food microbiology and spoilage mechanisms.	L1
CO2	Explain the various food preservation technologies and their applications in extending the shelf life of food products.	L2
CO3	Apply food processing and fermentation techniques to produce high-quality food products, considering nutritional and regulatory aspects.	L3
CO4	Analyze the role of biotechnology in improving food processing, including the use of enzymes and genetically modified organisms for enhanced nutritional value.	L4
CO5	Evaluate food quality assurance and control measures, including microbiological and chemical safety, food adulteration, and compliance with regulatory standards.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	PO9
10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	P10
11	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					2
CO2	3	2					2					
CO3			3	2		2			2			
CO4		3		3	3							
CO5						3		3		2		

Semester- II

NANOBIOTECHNOLOGY			
Course Code	MBBC214E	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- provide an understanding of the history, scope, and applications of nanomaterials and nanobiomaterials, including various structures and properties of carbon-based, metal-based, and bio-nanomaterials.
- To familiarize students with the techniques used to characterize nanostructures, including various types of microscopy and spectroscopy methods.
- To educate students on the methods of synthesizing and fabricating nanomaterials, including top-down and bottom-up approaches, lithography techniques, and biosensor applications.
- To explore the applications of nanobiotechnology in medicine, including diagnostics, therapeutics, drug delivery systems, nano-surgery, and tissue engineering.
- To provide insights into the ethical, legal, and social implications of nanotechnology, including safety concerns, health risks, regulatory aspects, and environmental effects.

Module-1

INTRODUCTION TO NANOMATERIALS AND NANOBIOMATERIALS:
History of Nanotechnology and Nanobiotechnology, scope and Applications. Structures and properties of Carbon based, metal based and bionanomaterails: Fullerenes, Bucky Ball, Nanotubes, Quantum Dots, Magnetic, Nano Shells, Dendrimers, Nanocarriers, Nanocrystals, Nanowires, Nanomembranes, hybrid biological/inorganic, protein & DNA based nanostructures. Introduction & overview of 1st , 2nd and 3rd generation biomaterials

Module-2

CHARACTERIZATION OF NANOSTRUCTURES:
UV-Visible spectroscopy, Electron Microscopy-Scanning electron microscopy (SEM), Atomic Force microscopy (AFM), Transmission electron microscopy (TEM), Scanning Probe microscopy (SPM), Scanning tunnel microscopy (STM); Fourier Transform infrared spectroscopy (FTIR); X-ray

Module-3

NANO SYNTHESIS AND FABRICATION:
Introduction & overview of Nanofabrication: Bottom up-self-assembly and Top down approaches using processes like Ball milling, Sol-gel Process, Chemical Vapor deposition (CVD). Plasma or flame spraying synthesis, Ion-Bean sculpting electrodeposition and various lithography techniques. Nanolithography and Soft lithography. Biosensors: types, applications and developments. Biosensor in modern medicine.

Module-4

APPLICATION OF NANOBIOTECHNOLOGY:
Medical Nanobiotechnology: Diagnostics: Imaging: Benefits and Applications. Nanotherapeutics: cancer treatment – Nanotechnology based chemotherapy (Smart Bomb), Pebbles, wound care products, Implantable materials for vascular interventions, Implantables materials for orthopaedics and dentistry. Active implantable devices and biomics. Nanosurgery. Pharmaceutical Nanobiotechnology: Drug delivery – Nanoparticles used as drug delivery systems, types of drug loading, drug release (sustained and targeted release mechanism), Biodegradable polymers. Application in the field of Nano Surgery and Tissue Engineering. Nano Safety Issues: Nanotoxicology: Toxicology health effects caused by Nanoparticles, Ethics Challenges and Future.

Module-5

ETHICS, SAFETY AND REGULATORY ASPECTS :
Introduction, ethical, legal and social implications of Nano medicine, and nano- bio-products, Safety concerns-Health Risks, and Challenges. Assessment of the toxic effects of nanoparticles based on in-vitro & In- Vivo experiments. Case studies. Environmental effects, public perceptions, Guidelines and regulatory aspects and evaluation of Nano pharmaceuticals in India, Europe and USA, challenges and risks associated with Markets for Nano medicine. Trends in Research and education

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Nanoparticle technology handbook, Masuo Hosokawa, Elsvier, 2012
2. Nanotechnology in biology and medicine, Tuvan ho Dhin, CRC press, 2006
3. The handbook of nanomedicine, Kewal K. Jain, Humana press, 2008
4. Essential of nanotechnology, Jereme Ramsden, Ventus publishing, 2006
5. NanoBiotechnology Protocols, Sandra J. Rosenthal and David W. Wright, Humana press, 2005
6. Nanobiotechnology Human Health and the Environment, by Alok Dhawan, Sanjay Singh, Ashutosh Kumar Rishi Shanker, CRC Oress,2018
7. The nanobiotechnology handbook, Yubing Xie, CRC press, 2013

Web links and Video Lectures (e-Resources):

1. https://www.udemy.com/course/nanotechnology
2. https://www.coursera.org/courses?query=nanotechnology
3. https://stores.biotecnika.org/products/nanobiotechnology-certification-course
4. https://www.edx.org/learn/nanotechnology
5. https://www.classcentral.com/subject/nanotechnology

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the basic concepts and history of nanomaterials and nanobiomaterials, including the structures and properties of various types of nanomaterials.	L1
CO2	Explain the principles and techniques used in the characterization of nanostructures, including microscopy and spectroscopy methods.	L2
CO3	Apply nano synthesis and fabrication techniques in practical scenarios, including the development of biosensors and other nanomaterial-based applications.	L3
CO4	Analyze the applications of nanobiotechnology in medicine, focusing on diagnostics, therapeutics, and drug delivery systems.	L4
CO5	Evaluate the ethical, safety, and regulatory aspects of nanotechnology, including the assessment of health risks and environmental impacts.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					2
CO2	3	2			2							
CO3			3	2	2							
CO4		3				2	2					
CO5						3		2				2

Semester- II

AGRICULTURAL BIOTECHNOLOGY			
Course Code	MBBC214F	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide an understanding of the history, scope, and importance of agricultural biotechnology, with a focus on staple crops, agro-climatic zones, and conventional crop improvement programs.
- To introduce students to the applications of plant transformation technology, including disease resistance, salinity and drought tolerance, herbicide and insecticide resistance, and integrated pest management.
- To educate students on the principles and practices of plant cell culture, including explant selection, media preparation, callus culture, somatic embryogenesis, and protoplast technology for crop improvement.
- To explore the role of antisense RNA technology in delaying fruit ripening, extending shelf life, and fortifying agricultural products, as well as the importance of biofertilizers in agriculture.
- To provide insights into the ethical, legal, and socioeconomic implications of biotechnology, including public perception, biosafety management, and the Cartagena Protocol on Biosafety.

Module-1

INTRODUCTION TO AGRICULTURAL BIOTECHNOLOGY:
Introduction, history and scope of agriculture in India. Staple food, fiber, fuel and fruit crops of India and abroad, Agro-climatic zones and cropping pattern of India. Conventional crop improvement programs- Introduction, Selection and Hybridization, Mutation, Haploidyand Polyploidy Breeding. Modern agriculture biotechnology for food security and national economy. Green-revolution.

Module-2

APPLICATIONS OF PLANT TRANSFORMATION TECHNOLOGY:
Productivity and performance disease resistance, genes and gene constructs used for viral resistance by coat protein mediated production, bacterial resistance by lysozyme gene and fungal resistance by chitinase and beta glucanase genes. Agrobacterium mediated transformation. Crop improvement to resist adverse soil conditions. Salinity tolerance, drought resistance. Herbicide resistance in commercially important plants. Insecticide resistance through BT-gene. Integrated pest management. Current status of BT crops in the world. Effect of transgenic crops on environment

Module-3

INTRODUCTION TO PLANT CELL CULTURE:
Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2; Callus and cell suspension culture; plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds"; haploid production: advantages and methods. Protoplast technology

Module-4

ANTISENSE RNA TECHNOLOGY (ACC synthase gene and polygalacturonase):
Delay of softening and ripening of fleshy fruits by antisense RNA for ACC synthase gene in tomato, banana. Use of antisense RNA technology for extending shelf life of fruits and flowers Protection of cereals, millets and pulses following harvest using biotechnology. Biotechnology for fortification of agricultural products- Golden rice, transgenic sweet potatoes. Importance of biofertlilizers in agriculture. (*Rhizobium azatobacter, Mycorrhiza, Frankia* and Blue green algae) current practices and production of biofertilizers.

Module-5

AN OVERVIEW OF LEGAL AND SOCIOECONOMICIMPACT OF BIOTECHNOLOGY:
Biotechnology & hunger. Ethical issues associated with labelling and consumption of GM foods. Public perception of GM technology. Biosafety management. Cartagena protocol on biosafety. Ethical implication of BT products, public education, Biosafety regulations, experimental protocol approvals, guidelines for research, environmental aspects of BT applications

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Genetic Engineering and Biotechnology: Concepts, Methods and Applications by Chopra VL & Nasim
2. A. Oxford & IBH.1990.
3. Elements of Biotechnology by Gupta PK, Rastogi Publ. 1997.
4. An Introduction to Recombinant DNA Technology: Basic Experiments in Gene Manipulation by Hackett PB, Fuchs JA &Messing JW2nd Ed. Benjamin Publ. Co., 1988.
5. Molecular Cloning, a Laboratory Manual by Sambrook J &Russel D.,3rd Ed. Cold Spring Harbor Lab. Press.2001.
6. Biotechnology, Expanding Horizons by Singh BD. Kalyani, 2005.
7. Molecular Biology & Genetic Engineering by L M Narayanan, A. Mani, A.M Selvaraj, N Arumugam, Padmalatha Singh, Saras Publication. 2014

Web links and Video Lectures (e-Resources):

1. https://www.classcentral.com/course/food-production-agricultural-technology-plant-bio-14399
2. https://www.futurelearn.com/courses/food-production-agricultural-technology-plant-biotechnology
3. https://www.mooc-list.com/tags/plant-biotechnology
4. https://onlinecourses.nptel.ac.in/noc19_bt21/preview
5. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the fundamental concepts of agricultural biotechnology, including crop improvement programs and agro-climatic zones.	L1
CO2	Explain the applications of plant transformation technology, including gene constructs for disease resistance and stress tolerance.	L2
CO3	Apply plant cell culture techniques in the context of crop improvement, including somatic embryogenesis and protoplast technology.	L3
CO4	Analyze the effectiveness of antisense RNA technology in extending the shelf life of agricultural products and its role in biofortification.	L4
CO5	Evaluate the ethical and legal considerations associated with biotechnology, including public perception, biosafety regulations, and the Cartagena Protocol.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	PO9
10	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					2
CO2		3		2								
CO3			3		2						2	
CO4				3	3	2						
CO5						3		3				3

Semester- II

SYSTEMS BIOLOGY AND MEDICAL INFORMATICS			
Course Code	MBBC214G	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of systems biology, including its scope, applications, and practical implementations using mathematical and experimental techniques.
- To introduce students to standard models and approaches in systems biology, including metabolic control analysis, signal transduction, and gene expression modeling.
- To explore the applications of systems biology in real-world scenarios, such as metabolic network reconstruction, integrated regulatory models, and multi-scale representations of cells.
- To familiarize students with the concepts, historical perspectives, and future trends in medical informatics, including the application of IT in healthcare systems.
- To equip students with knowledge of AI/ML, expert systems, and the critical issues in medical data management, including legal, security, and privacy concerns.

Module-1

INTRODUCTION TO SYSTEMS BIOLOGY:
Scope, Applications. Systems Biology in Practice Concepts Implementation and Applications. Mathematics in a Nutshell. Experimental Techniques in a Nutshell. Modeling Tools: SBML, MathML, CellML, Petri Nets and Bioinformatics. Data Integration - bicluster, mutual information, data warehouse. Databases related to systems biology

Module-2

STANDARD MODELS AND APPROACHES IN SYSTEMS BIOLOGY
Metabolic control analysis, metabolic network, Michaelis-Menten kinetics. Signal Transduction - phosphorylation, Jak-Stat pathway, MAP kinase. Biological Processes – mitochondria. Modelling of Gene Expression - lactose, lac operon, tRNA. Analysis of Gene Expression Data - support vector machines, cDNA, microarray. Evolution and Self organization - hypercycle, quasispecies model, self-replication.

Module-3

APPLICATIONS OF SYSTEMS BIOLOGY:
Standards Platforms and Applications - metabolic control analysis, glycolysis, flux balance analysis. Biological Foundations of Signal transduction and the Systems - phosphorylation, microRNAs, protein kinase. Reconstruction of Metabolic Network from Genome Information and Integrated Regulatory and Metabolic Models - phosphorylation, gene expression, metabolites. Integrated Regulatory and Metabolic Models - phosphorylation, gene expression, metabolites. Estimation Modeling and Simulation - circadian rhythms, Petri net, mRNA. Deterministic - circadian rhythms, mRNA, circadian oscillations. MultiScale Representations of Cells and Emerging Phenotypes - Gene Regulatory Networks.

Module-4

MEDICAL INFORMATICS:
Aim and scope, historical perspectives, concepts and activities in medical informatics, definition of medical informatics, introduction to the application of information technology to integrated hospital information systems and patient-specific information; nursing, radiology, pathology, and pharmacy services, Future trends, research in medical informatics, training and opportunities in medical informatics

Module-5

AN KNOWLEDGE BASED EXPERT SYSTEMS:
AI/ML, expert systems, materials and methods, applications of ES, Introduction to computer based patient record, development tools, CPR in radiology, legal security and private issues, application service providers. Critical medical issues: security, confidentiality, privacy, accuracy and access. Data Management for Clinical Research, Data Visualization and Analytics, EHRs and Clinical Decision Support Systems, Clinical Decision Making. Role of a CHIO, Enterprise Data Strategy Health Information Exchange, Data Standards, Geospatial Analysis and Social Determinants, Human Factors in User Interface Design, SMART on FHIR, Public Health Informatics.

Assessment Details (both CIE and SEE)

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credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. A First Course in Systems Biology by Voit E ,Garland Science, 2012
2. Systems biology by Klipp E, Wiley-VCH, 2009.
3. Networks: an introduction. By Newman, Oxford Univ. Press. MEJ, 2011.
4. An Introduction to Systems Biology: Design Principles of Biological Circuits. By Alon, Uri. Chapman&
5. Hall /CRC, 2006.
6. Radiological Imaging, The Theory of Image Formation, Detection, and Processing by Harrison Barrett and William Swindell, Academic Press,1996.
7. Introduction to Biomedical Imaging by Andrew G. Webb, Wiley, 2017.
8. Medical Imaging Systems by A. Macovski by R. Bracewell, Springer ebook, 2018.

Web links and Video Lectures (e-Resources):

1. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource https://www.coursera.org/courses?query=system%20biology
2. https://onlinecourses.nptel.ac.in/noc20_bt08/preview
3. https://ocw.mit.edu/courses/8-591j-systems-biology-fall-2014/

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the basic concepts of systems biology and its applications	L1
CO2	Explain the standard models and approaches in systems biology, such as metabolic control analysis and gene expression modeling.	L2
CO3	Apply systems biology principles to real-world scenarios, such as metabolic network reconstruction and multi-scale representations.	L3
CO4	nalyze the role of medical informatics in healthcare systems, including the integration of IT and the impact on patient-specific information.	L4
CO5	Evaluate the use of AI/ML and expert systems in medical data management, considering legal, security, and privacy concerns.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
8	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	PO10
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	2			1							
CO2	3	2	1									
CO3			3	3	2							
CO4		3		3						2		
CO5						3		3				2

Semester- II

PHARMACEUTICAL BIOTECHNOLOGY			
Course Code	MBBC215A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Develop a foundational knowledge of pharmaceutical biotechnology, including pharmacokinetics, current research trends, and manufacturing principles.
- Study various biotechnological therapeutics such as growth factors, hormones, antibiotics, vaccines, and their applications in healthcare.
- Learn about biotransformation methods, including steroid transformation and monoclonal antibody production, and their significance in pharmaceutical applications.
- Understand the role of nutraceuticals in healthcare, their nutritional importance, and explore different drug delivery systems and their mechanisms.
- Investigate the application of recombinant proteins and proteomics in drug development and their prospects in the pharmaceutical industry.

Module-1

INTRODUCTION:
Introduction to pharmaceutical biotechnology, pharmacokinetic concepts, current research trends, new advances and approved biologicals for pharmaceutical use and manufacturing principles. Quality assurance and control; Concept of GMP, GLP.

Module-2

THERAPEUTICS BASED ON BIOTECHNOLOGY:
Hematopoietic growth factor and coagulation factors, interferons and cytokines; Preparation and standardization of hormones-thyroid, insulin and growth hormones; Enzymes-Enzymatic therapy and monographs; antibiotics and their derivatives-penicillin, streptomycin, tetracycline, cephalosporins, macrolides, peptide antibiotics (any two); vaccines BCG, DPT, Poliomyelitis, Typhus, toxoids-diptheria and tetanus; antitoxins diptheria and gas-gangrene(any two); others-whole human blood, dried human plasma, gamma globulins, clinical dextran and absorbable haemostats, uses, and storage

Module-3

BIOTRANSFORMATION:
Introduction, methods used in biotransformation, steroid transformation, contraceptives, L-Dopa, chemical reactions and mechanisms(hydroxylation, aromatization, synthetic routes, epoxidation and others), production and application of monoclonal antibodies.

Module-4

NUTRACEUTICALS:
Antioxidants, flavonoids, carotenoids, cholesterol lowering chemicals, nutritional importance and their functions, deficiency diseases, nutritional status evaluation. Drug delivery systems: Introduction to drug delivery systems and methods, overview of barriers, calculation of drug metabolism and, pharmacodynamics.

Module-5

RECOMBINANT PROTEINS AND PROTEOMICS IN DRUG DEVELOPMENT:
Role of proteomics in drug development Application of recombinant proteins in pharmaceutical industry, health care and prospects.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Biopharmaceuticals: Biochemistry and Biotechnology, Walsh G John, Wiley & Sons Ltd, 2003
2. Pharmaceutical :Fundamentals and Applications, Crommelin, Daan J. A., Sindelar, Robert D., Meibohm, Springer, 2013
3. Wolff Burger's Medicinal Chemistry and Drug Discovery, Manfred E Wiley & Sons Inc., 2000.
4. Drug delivery: principles and applications, Binghewang, Terunasiahaan, Richard Soltero, John Wiley & Sons, 2005.
5. Drug Metabolism: An Introduction, Michael D. Coleman, John Wiley & Sons, 2005

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102105058
2. https://archive.nptel.ac.in/courses/126/104/126104004/
3. https://dth.ac.in/medical/course-inner.php?id=278
4. https://onlinecourses.swayam2.ac.in/ugc19_hs33/preview
5. https://onlinecourses.nptel.ac.in/noc19_bt26/preview
6. https://archive.nptel.ac.in/courses/102/106/102106070/

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Define key concepts in pharmaceutical biotechnology, such as pharmacokinetics, biotransformation, and nutraceuticals.	L1
CO2	Explain the mechanisms of drug delivery systems, the role of proteomics, and the importance of GMP and GLP in biotechnology.	L2
CO3	Demonstrate the preparation and standardization of biotechnological therapeutics, such as hormones, antibiotics, and vaccines.	L3
CO4	Analyze the processes involved in biotransformation and drug metabolism, and evaluate their implications in drug development.	L4
CO5	Assess the potential of recombinant proteins and proteomics in the pharmaceutical industry, considering ethical and regulatory issues.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	1										
CO2	3					2						
CO3			3		2							
CO4		3		2								
CO5							3	2				

Semester- II

METABOLIC ENGINEERING			
Course Code	MBBC215B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a deep understanding of the structure, classification, and mechanical properties of biomaterials, including nanomaterials, composites, and their interactions with biological tissues.
- To impart detailed knowledge on metallic, ceramic, synthetic, and biopolymer materials used in medical applications, focusing on their properties and biocompatibility.
- To introduce students to advanced methods of biomaterial characterization, in-vitro and in-vivo testing, and safety evaluations for medical devices.
- To explore the design, functionality, and integration of biomaterials in artificial organs and prosthetic devices.
- To discuss the latest applications of biomaterials in areas such as drug delivery, tissue engineering, and regenerative medicine, with attention to ethical and regulatory considerations.

Module-1

INTRODUCTION AND METABOLIC REGULATION:
Introduction: Importance of metabolic engineering and its multidisciplinary nature. An overview of Cellular Metabolism, Transport Processes, Passive Transport, Facilitated Diffusion, Active Transport, Fueling Reactions, Fermentative Pathways, Glycolysis, TCA Cycle and Oxidative Phosphorylation, Anaplerotic Pathways, Catabolism of Fats, Organic Acids, and Amino Acids, Biosynthetic Reaction, Biosynthesis of Amino Acids Biosynthesis of Nucleic Acids, Fatty Acids.

Module-2

METABOLIC FLUX AND APPLICATIONS OF METABOLIC FLUX ANALYSIS:
Metabolic flux analysis and its application, Methods for experimental determination of metabolic flux by isotope dilution method. Production of Glutamic Acid and regulation by Bacteria, Calculation of Theoretical Yields, Metabolic Flux Analysis of Lysine Biosynthetic Network in *C. glutamicum*, Metabolic Flux Analysis of Specific Deletion Mutants of *C. glutamicum*, Metabolic Fluxes in Mammalian Cell Cultures, Determination of Intracellular Fluxes, Application of Flux Analysis to the Design of Cell Culture Media.

Module-3

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

Module-4

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

Module-5

BIOSYNTHESIS OF METABOLITES AND BIOCONVERSIONS:
Primary metabolites: Alteration of feedback regulation, limiting of accumulation of end products, resistant mutants. Secondary metabolites: Precursor effects, prophage, idiophase relationship, enzyme induction, feedback repression, catabolic repression, important groups of secondary metabolic enzymes, phosphotransferase, ligases oxidoreductases, oxygenases, carboxylases. Advantages of bioconversions, specificity, yields. Factors important to bioconversions, regulation of enzyme synthesis, permeability co metabolism, conversion of insoluble substrates.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the

credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Metabolic Engineering Principles and Methodologies, Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens
2. Nielsen, Academic Press, 1998
3. Control of metabolic process A.C. Bowden and, M.L. Cardens, Plenum Publisher, 1991
4. Bioprocess engineering basic concepts, M.L. Shuler and Kargi, Pearson Hall, 1992
5. Fermentation and enzyme Technology, Wang D I C Cooney C I Demain, A L John Willey, 1992
6. Scale-up Methods in Chemical Engineering, Johnson and Thring, Johnson and Thring, 2006

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102105086
2. https://www.digimat.in/nptel/courses/video/102105086/L01.html
3. https://nptel.ac.in/courses/102105086
4. https://onlinecourses.nptel.ac.in/noc22_bt29/preview
5. https://nptel.ac.in/courses/104103121

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Define and classify various biomaterials, including their mechanical properties and types.	L1
CO2	Explain the tissue-biomaterial interactions and the factors influencing biocompatibility.	L2
CO3	Demonstrate the application of metallic and ceramic materials in the design of medical implants.	L3
CO4	Analyze the synthesis and properties of synthetic and biopolymer materials for specific biomedical applications.	L4
CO5	Evaluate the ethical and regulatory considerations involved in the development and application of advanced biomaterials.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					
CO2		3				2						
CO3			3		2							
CO4				3			2					
CO5								3				2

Semester- II

BIOMATERIALS & ARTIFICIAL ORGANS			
Course Code	MBBC215C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide students with a comprehensive understanding of the definition, classification, and mechanical properties of biomaterials, including nanomaterials and composites.
- To impart knowledge on various metallic, ceramic, synthetic, and biopolymer materials used in medical applications, focusing on their properties and interactions with biological tissues.
- To introduce students to the methods of biomaterial testing, including in-vitro and in-vivo pre-clinical tests, with a focus on safety and biocompatibility evaluation.
- To explore the design and application of artificial organs and prosthetic devices, emphasizing the integration of biomaterials in these medical technologies.
- To discuss the latest advancements in biomaterial applications, including drug delivery systems, tissue engineering, regenerative medicine, and ethical issues surrounding these technologies.

Module-1

STRUCTURE OF BIO-MATERIALS AND BIO-COMPATIBILITY

Definition and classification of bio-materials, mechanical properties, composite materials, Nanomaterials and nanocomposites, Tissue-biomaterial interactions, biomaterial characterization, medical devices, Testing of biomaterials: In-vitro, in-vivo pre-clinical tests, safety and biocompatibility evaluation

Module-2

METALS AND CERAMICS

Metallic implant materials, stainless steels, Co-based alloys, Ti-based alloys, ceramic implant materials, aluminum oxides, hydro-apatite, glass ceramics, carbons

Module-3

SYNTHETIC AND BIOPOLYMERS

Polymerization, poly amides, Acrylic polymers, rubbers, high strength thermoplastics, Bio polymers: Collagen, Hyaluronic acid, chitosan and Elastin

Module-4

ARTIFICIAL ORGANS

Artificial Heart, Prosthetic Cardiac Valves, Limb prosthesis, Externally powered limb prosthesis, Dental Implants, Artificial cornea, Artificial liver and pancreas, artificial skin

Module-5

APPLICATIONS

Medical applications of biomaterials, Drug delivery, Bioinspired Materials and Biomimetics, Tissue engineering, Regenerative medicine, Stem cell biology, modern scaffold structures, advanced fabrication technologies including computer-aided tissue engineering and organ printing, global regulatory requirements, technology transfer and ethical issues

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. An Introduction to Biomaterials, J. B. Park and R. S. Lakes, Springer, 2007
2. Biological Performance of materials, J. Black, Taylor & Francis, 2005
3. Biomaterials Science: An Introduction to Materials in Medicine. Buddy D. Ratner et al. Elsevier, 2004.
4. Essential Biomaterials: Cambridge Texts in Biomedical Engineering. David Williams 2014, 1st edition.
5. Polymeric Biomaterials, Piskin and A S Hoffmann, Martinus Nijhoff Springer, 1986

Web links and Video Lectures (e-Resources):

1. https://www.udemy.com/course/draft/3729862/
2. https://www.edx.org/learn/biomaterials
3. https://onlinecourses.nptel.ac.in/noc20_bt12/preview
4. https://www.mooc-list.com/tags/biomaterials

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Define and classify different types of biomaterials and their properties.	L1
CO2	Explain the interactions between biomaterials and biological tissues, and the factors affecting biocompatibility	L2
CO3	Demonstrate the process of selecting appropriate materials for specific medical applications, such as implants and prostheses.	L3
CO4	Analyze the structure and functionality of artificial organs and assess the effectiveness of various biomaterials used in their design.	L4
CO5	Evaluate the safety, efficacy, and ethical implications of using advanced biomaterials in medical applications, such as tissue engineering and drug delivery systems.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					
CO2		3				2						
CO3			3		2							
CO4				3			2					
CO5								3				2

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Semester- II

VACCINE TECHNOLOGY			
Course Code	MBBC215D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of immune tolerance, autoimmunity, hypersensitive reactions, immunodeficiencies, and the immune response to infectious diseases.
- To introduce students to traditional and modern methods of vaccine production, including the scientific principles behind the design and screening of vaccines.
- To delve into various types of vaccines, such as live, killed, attenuated, subunit, and recombinant vaccines, and understand the role of adjuvants and the principles of antiviral mechanisms.
- To educate students on the manufacturing processes, safety, legal, and regulatory issues associated with vaccine production, with an emphasis on large-scale manufacturing and quality control.
- To apply comparative genomics as a tool for vaccine design, including the identification and application of T and B cell epitopes.

Module-1

IMMUNOPATHOLOGY:
Tolerance and Autoimmunity, Hypersensitive reactions, Primary and Secondary Immunodeficiency, Active and passive immunization, General immunization practices, , AIDS, Immune response to Infectious disease, Basic principles of vaccine development. Vaccination of immune-compromised hosts, Vaccination of human immunodeficiency virus- infected persons. Vaccines and its historical perspective

Module-2

PROCESS
Traditional and modern methods of vaccine production, Egg and cell based vaccine development, Current and future scenario of Vaccines, Edible Vaccines, Reverse vaccinology, Immunoinformatics approach to identify T and B cell epitopes, Bacterial and Viral vaccine. Passive immunization; antibody, transfusion of immune competent cells, cell based vaccines. Immunomodulators (cytokines) Innovative methods of delivery of immunogens through

Module-3

VACCINE TECHNOLOGY:
Criteria for effective vaccine, Vaccines, Live, killed, attenuated, sub unit vaccines; Role and properties of adjuvants, recombinant DNA and protein based vaccines, Multivalent subunit vaccines, mini cell vaccines, conjugate vaccines plant-based vaccines, recombinant antigens as vaccines. Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretrovirals— mechanism of action and drug resistance. Comparative Genomics as a tool for vaccine design.

Module-4

TYPES OF VACCINES
Licensed vaccines, Viral Vaccine (Poliovirus vaccine-inactivated & Live, Rabies vaccines Hepatitis A & B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine). Vaccines against Hepatitis A, Malaria, Typhoid (in clinical trials). Conventional vaccines, antiidiotype vaccine, naked DNA vaccine. Recombinant Vaccines - Definition, recombinant vector vaccines, DNA vaccines. Vaccine potency testing.

Module-5

INDUSTRY AND ISSUES
The vaccine industry, Vaccine manufacturing, Vaccine additives and manufacturing residuals, Regulation and testing of vaccines, Vaccine safety and Legal issues. Regulatory issues- Environmental concerns with the use of recombinant vaccines, Disease security and biosecurity principles and OIE guidelines Method of manufacture- in process control, batch control, test on final products. large scale manufacturing—QA/QC issues.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Vaccines Stanley A. Plotkin& year Walter Orenstein & Paul A. Offit Elsevier Publication 2013
2. Clinical Immunology Brostoff J, Seaddin JK, Male D, Roitt IM Gower Medical Publishing 2002
3. Essential Immunology Roitt, I Blackwell Scientific Publications 2001
4. New Vaccine Technologies Ronald W. Ellis Landes Bioscience 2001
5. Cheryl Barton Advances in Vaccine Technology and Delivery Espicom Business intelligence 2009

Web links and Video Lectures (e-Resources):

1. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Students will recall and describe key concepts in immunopathology and vaccine development.	L1
CO2	Students will apply knowledge to analyze immune responses to vaccines and infectious diseases.	L2
CO3	Students will design and propose effective vaccine strategies based on immunological principles and modern techniques.	L3
CO4	Students will evaluate the safety, legal, and regulatory challenges in vaccine production.	L4
CO5	Students will synthesize information and create innovative vaccine solutions using advanced immunological techniques.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
7	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
8	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	P11
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	P12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											2
CO2		3		2								
CO3			3		2		1					
CO4						3		2			1	
CO5			3								2	1

Semester- II

WASTE MANAGEMENT

Course Code	MBBC215E	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of the classification of solid wastes based on source and type, and introduce the elements and technologies used in environmentally sound solid waste management.
- To equip students with the knowledge and skills to assess waste generation, composition, and characteristics, including the environmental and health impacts of waste.
- To teach the principles of waste collection, storage, transportation, and disposal, including the design of waste collection systems and the operation of sanitary landfills.
- To introduce students to various waste processing techniques, including mechanical volume reduction and recycling, and to explore methods for source reduction and product recovery.
- To provide insights into the identification, classification, and treatment of hazardous waste, including pollution prevention, waste minimization, and the management of hazardous wastes in India.

Module-1

INTRODUCTION TO SOLID WASTE MANAGEMENT:
Classification of solid wastes (source and type based), solid waste management (SWM), elements of SWM, ESSWM(environmentally sound solid waste management) and EST (environmentally sound technologies), factors affecting SWM, Indian scenario, progress in MSW (municipal solid waste) management in India.

Module-2

WASTE GENERATION ASPECTS:
Waste stream assessment (WSA), waste generation and composition, waste characteristics (physical and chemical), health and environmental effects (public health and environmental), comparative assessment of waste generation and composition of developing and developed nations, a case study results from an Indian city, handouts on solid waste compositions.

Module-3

COLLECTION, STORAGE, TRANSPORT AND DISPOSAL OF WASTES:
Waste Collection, Storage and Transport: Collection components, storage-containers/collection vehicles, collection operation, transfer station, waste collection system design, record keeping, control, inventory and monitoring, implementing collection and transfer system, a case study. Waste Disposal: key issues in waste disposal, disposal options and selection criteria, sanitary landfill, landfill gas emission, leachate formation, environmental effects of landfill, landfill operation issues, a case study.

Module-4

WASTE PROCESSING TECHNIQUES & SOURCE REDUCTION, PRODUCT RECOVERY & RECYCLING:
Purpose of processing, mechanical volume and size reduction, component separation, drying and dewatering. Source Reduction, Product Recovery and Recycling: basics, purpose, implementation monitoring and evaluation of source reduction, significance of recycling, planning of a recycling programme, recycling programme elements, commonly recycled materials and processes, a case study.

Module-5

HAZARDOUS WASTE MANAGEMENT AND TREATMENT:
Identification and classification of hazardous waste, hazardous waste treatment, pollution prevention and waste minimization, hazardous wastes management in India.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. George Tchobanoglous et.al., "Integrated Solid Waste Management", McGraw-Hill Publishers, 1993.
2. B. Bilitewski, G. Hard He, K. Marek, A. Weissbach, and H. Boeddicker, "Waste Management", Springer, 1994.
3. Solid Wastes-Engineering Principles and Management Issues, Tchobanoglous, G., Theisen, H., and Eliassan, R. McGraw-Hill Series, Kogakusha, Ltd. 1977
4. Integrated Solid Waste Management, McGraw-Hill, Inc., New Delhi. Tchobaanoglous, G., Theisen, H., and Samuel A Vigil,1993.
5. Integrated solid waste management: a life cycle inventory. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. John Wiley & Sons. 2001
6. Handbook of solid waste management and waste minimization technologies, Nicholas, P., & Cheremisinoff, P. D., Imprint of Elsevier Science. 2005

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/105103205
2. https://www.youtube.com/watch?v=k0ktJRoRcOA
3. https://nptel.ac.in/courses/103/107/103107125/
4. https://onlinecourses.nptel.ac.in/noc22_ce76/preview
5. https://onlinecourses.swayam2.ac.in/cec20_ge13/preview

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and recall key concepts related to the classification, elements, and technologies used in solid waste management.	L1
CO2	Explain the processes of waste generation, composition assessment, and the environmental and health impacts of waste.	L2
CO3	Apply principles of waste collection, storage, transportation, and disposal to design effective waste management systems.	L3
CO4	Analyze waste processing techniques and recycling methods to optimize source reduction and product recovery in waste management.	L4
CO5	Evaluate hazardous waste management practices, including treatment methods and minimization strategies, within the context of Indian regulations.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
3	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	PO4
4	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
5	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	PO6
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development	PO7
7	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	PO9
	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	PO11
	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3		1									
CO2	2					1	2					
CO3			3								2	
CO4				3	2							1
CO5							3	2	1			

Semester- II

PROTEIN ENGINEERING & INSILICO DRUG DESIGN			
Course Code	MBBC215F	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Develop a foundational understanding of protein structures, including the building blocks, motifs, and folding mechanisms.
- Study the thermodynamics of macromolecular recognition, focusing on protein-protein and protein-DNA interactions.
- Gain insights into advanced techniques such as NMR spectroscopy, crystallography, and calorimetric methods for protein characterization and engineering applications.
- Learn and apply cutting-edge techniques in protein engineering, including directed evolution, rational design, and combinatorial enzyme engineering.
- Acquire skills in molecular modeling, receptor mapping, and docking methods, with practical applications in drug design and structural biology.

Module-1

INTRODUCTION TO PROTEIN STRUCTURE:
The Building Blocks, Motifs of Protein Structure, Protein folding Molecular Recognition: Protein-protein interactions, Protein-DNA interactions, The Thermodynamics of Binding like thermal stability and specificity of Macromolecular Recognition, Transcription, translation, and post-translational modifications of proteins.

Module-2

CHARACTERIZATION & APPLICATIONS OF PROTEIN ENGINEERING:
NMR spectroscopy, crystallography, spectroscopic and calorimetric methods. Design of polymeric biomaterials, nicotinic acetylcholine receptors as a model for a super family of ligand – gated ion channel proteins

Module-3

ADVANCED PROTEIN ENGINEERING: DESIGN PRINCIPLES AND CUTTING-EDGE TECHNIQUES
Protein design principles, Student design proposals, Protein engineering by directed evolution and rational design, Directed Evolution Strategy- Phage Display Systems, Cell Surface Display Systems, Cell Free Display System, Alternative Scaffolds, Combinatorial Enzyme Engineering, Protein Engineering using noncanonical amino acids.

Module-4

MOLECULAR MODELING:
Constructing an Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure Generation or Retrieval, Structure Visualization, Conformation Generation, Deriving Bioactive Conformations, Molecule Superposition and Alignment, Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Calculation of Molecular Properties, Examples of Small Molecular Modeling Work, Nicotinic Ligands. INSILICO DRUG DESIGN: Generation of Rational Approaches in Drug Design, Molecular Modeling: The Second Generation, Conceptual Frame and Methodology of Molecular Modeling, The Field Currently Covered, Importance of the "Bioactive Conformation", Molecular Mimicry, Structural Similarities and Superimposition Techniques, An Important Key and the Role of the Molecular Model, Limitations of Chemical Intuition Major Milestones and Future Perspectives.

Module-5

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the

credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Protein Engineering Protocols, Katja Arndt, Kristian Müller, Humana Press, 2017, ISBN:9781597451871, 1597451878
2. Protein Engineering and Design, 1st Edition, Sheldon J. Park, Jennifer R. Cochran, CRC Press ,Published September 25, 2009, B/W Illustrations ,ISBN 9781420076585 - CAT# 76582

Web links and Video Lectures (e-Resources):

1. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
2. https://in.coursera.org/learn/drug-discovery

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and describe the basic building blocks and motifs of protein structures.	L1
CO2	Explain the principles of protein-protein interactions and the thermodynamics of binding.	L2
CO3	Utilize NMR spectroscopy and crystallography techniques to characterize protein structures.	L3
CO4	Analyze and interpret the results of protein engineering experiments using directed evolution and rational design methods.	L4
CO5	Evaluate molecular docking results and molecular models for accuracy in predicting protein-ligand interactions	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
5	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	1											1
CO2	2	2										
CO3	3				2							
CO4		3			3							
CO5			3		3		2					

Semester- II

BIOREACTOR DESIGN CONCEPTS			
Course Code	MBBC206	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To provide a comprehensive understanding of the principles and classifications of bioreactors, including the design and functionality of different types of bioreactors used in bioprocessing.
- To develop the ability to analyze microbial growth kinetics, product formation, and substrate utilization, with an emphasis on their applications in bioprocesses.
- To equip students with the knowledge and skills needed to design, scale-up, and optimize bioreactors for industrial applications, considering mass and heat transfer principles.
- To introduce the principles of instrumentation and control in bioreactors, including data acquisition, automation, and case studies on bioreactor control systems.
- To investigate real-world applications of bioreactor technology in various industries, with an emphasis on economic and environmental considerations.

Module-1

INTRODUCTION TO BIOREACTORS

Overview of bioreactors and their applications in biotechnology-Classification of bioreactors (batch, fed-batch, continuous, air-lift, packed-bed, fluidized-bed)-Basic components and functions of bioreactors-Importance of bioreactor design in bioprocessing-Key performance parameters (productivity, yield, selectivity).

Module-2

KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION

Microbial growth kinetics (batch and continuous cultures)-Monod equation and its applications-Product formation kinetics (growth-associated, non-growth-associated, and mixed-growth-associated)-Substrate utilization kinetics-Yield coefficients and maintenance energy.

Module-3

BIOREACTOR DESIGN AND SCALE-UP

Design principles of different types of bioreactors-Mixing and mass transfer in bioreactors (oxygen transfer, kLa, shear forces)-Heat transfer and temperature control in bioreactors-Scale-up principles and challenges-Design considerations for large-scale bioreactors,

Module-4

INSTRUMENTATION AND CONTROL IN BIOREACTORS

Instrumentation for monitoring and controlling bioreactor parameters (pH, temperature, dissolved oxygen, agitation)-Control strategies (PID control, feedforward, feedback control)-Data acquisition and analysis-Automation in bioreactor systems-Case studies on bioreactor control systems Facility design aspects and Utility supply aspects, Equipment cleaning aspects, Design considerations for maintaining sterility of process streams and process equipment, Materials of construction for bioprocess plants. Medium requirements and formulation for fermentation processes (examples of simple and complex media), design and usage of commercial media for industrial fermentations, Batch and continuous heat sterilization of liquid media, Filter sterilization of liquids, Air sterilization- Techniques involved, sterility test and integrity test, Inoculation process, sampling process, cell harvesting, Cooling of fermenter system, water system for bioprocess industry (production of triple distilled water), Primary packing and secondary packing, waste disposable technology, environmental aspects.

Module-5

APPLICATIONS AND CASE STUDIES IN BIOREACTOR DESIGN

Case studies on bioreactor applications in pharmaceuticals, food, and environmental biotechnology-Bioreactor design for specific applications (e.g., production of antibiotics, biofuels, enzymes)-Economic and environmental considerations in bioreactor design-Emerging trends and technologies in bioreactor design-Future challenges and opportunities in bioreactor technology.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). Principles of Fermentation Technology. Butterworth-Heinemann.
2. Biochemical Engineering Fundamentals Bailey and Ollis Prentice Hall 1992

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/102/106/102106086/

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and describe the basic components and classifications of bioreactors.	L1
CO2	Understand and apply the Monod equation and other kinetic models to microbial growth and product formation.	L2
CO3	Design bioreactors and apply principles of scale-up to address challenges in industrial bioprocesses.	L3
CO4	Analyze and implement control strategies in bioreactors, including PID control and automation systems.	L4
CO5	Critically evaluate case studies and the application of bioreactor technology in various industries, considering economic and environmental impacts.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	PO5
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
7	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8
8	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	PO9
9	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3						2					
CO2	3	2	2									
CO3				3	3				2			
CO4		3		2			2					
CO5							3	2				2

MOLECULAR BIOLOGY TECHNIQUES LAB			
Course Code	**MBBCL207**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:0	SEE Marks	50
Credits	2	Exam Hours	3

Course objectives:

- To familiarize students with the preparation of common molecular biology lab buffers such as TAE, TBE, and TE, essential for various molecular biology experiments.
- To equip students with techniques for isolating DNA and RNA from different biological samples and their quantification using electrophoresis and blotting methods.
- To introduce students to the principles and applications of Polymerase Chain Reaction (PCR) and genetic transformation techniques, including restriction digestion and ligation.
- To teach students the methodologies for isolating and quantifying proteins from various sources, using techniques like Western Blot.
- To develop skills in culturing, preparing competent cells, and performing genetic transformation in E. coli.

Sl.NO	Experiments
1	Preparations of common molecular biology lab buffers (TAE, TBE, TE, Tris-Hcl etc.)
2	Isolation of DNA (plant/microbial)
3	Agarose gel electrophoresis and quantification of DNA (Southern Blot)
4	Amplification of DNA by PCR.
5	Isolation of total RNA from bacteria/plant/animal samples
6	Quantification of RNA by Northern Blot/
7	Isolation of Proteins from different sources
8	Quantification of Protein (Western Blot)
9	Restriction Digestion of plasmid pUC18
10	Ligation of Gene of interest on the vector
11	Culture and Preparation of Competent *E.Coli* Cells for bacterial transformation
12	Genetic transformation of *E.coli*

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Recall the procedures for preparing molecular biology lab buffers such as TAE, TBE, and TE.
2. Understand the techniques for isolating and quantifying DNA and RNA from various sources and their application in Southern and Northern blotting.
3. Apply techniques such as PCR for DNA amplification and restriction digestion for plasmid analysis in molecular cloning.
4. Analyze the results of protein isolation and quantification using Western blotting, and evaluate the efficiency of gene ligation and transformation in bacterial cells.

5. Critically evaluate the outcomes of genetic transformations and the role of molecular techniques in biotechnological applications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology - M. Wink. Wiley, ed. 2, 2011.
2. Molecular and cellular Biology, Stephen L.Wolfe, Wadsworth Publishing Company, 1993
3. Molecular Biology LabFax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991
4. Electrophoresis in Practice: A Guide to Methods and Applications of DNA and Protein Separations, Fourth Edition; Dr. Reiner Westermeier,2004.

Course outcome (Course Skill Set)
At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the procedures for preparing molecular biology lab buffers such as TAE, TBE, and TE.	L1
CO2	Understand the techniques for isolating and quantifying DNA and RNA from various sources and their application in Southern and Northern blotting.	L2
CO3	Apply techniques such as PCR for DNA amplification and restriction digestion for plasmid analysis in molecular cloning.	L3
CO4	Analyze the results of protein isolation and quantification using Western blotting, and evaluate the efficiency of gene ligation and transformation in bacterial cells.	L4
CO5	Critically evaluate the outcomes of genetic transformations and the role of molecular techniques in biotechnological applications.	L5

Program outcome of this course

Sl no	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
7	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2	2	2										
CO3			3	3								
CO4				3		3						
CO5							3	2				

BIOPROCESS CONTROL AND AUTOMATION LAB			
Course Code	**MBBC258A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:0	SEE Marks	50
Credits	1	Exam Hours	2

Course objectives:

- To gain comprehensive knowledge of the characteristics and functions of flow, pressure, and temperature transducers.
- To understand the dynamic behaviour of first-order systems in response to various inputs such as step and pulse inputs.
- To explore the differences between interacting and non-interacting systems and how they respond to external stimuli.
- To analyze the response characteristics of temperature, pressure, and flow controllers to changes in set points and loads.
- To apply theoretical concepts to practical experiments, improving problem-solving and analytical skills in the field of control systems.

Sl.NO	Experiments
1	Characteristics of Transducers (Flow)
2	Characteristics of Transducers (Pressure)
3	Characteristics of Transducers (Temperature)
4	Dynamics of First order system (mercury thermometer) for step input
5	Dynamics of First order system (Single tank System) for step input and pulse input
6	Interacting System responses to step input
7	Interacting System responses to pulse input
8	Non-interacting system responses to step input
9	Non-interacting system responses to pulse input
10	Temperature controller – responses to set point / load change
11	Pressure controller – responses to set point / load change
12	Flow controller – responses to set point / load change

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Identify and describe the basic characteristics of flow, pressure, and temperature transducers.
2. Explain the dynamic behavior of first-order systems, including both mercury thermometers and single-tank systems, in response to step and pulse inputs.
3. Apply knowledge of system interactions to analyze the response of interacting and non-interacting systems to step and pulse inputs.
4. Evaluate the performance of temperature, pressure, and flow controllers in response to set point and load

changes.

5. Design experiments to investigate and optimize the characteristics of transducers and control systems, leading to innovative solutions for complex engineering problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Process System analysis and Control by Donald R Coughanowr, McGraw-Hill, 2013.
2. Chemical Process Control by George Stephanopoulos, Prentice-Hall of India, 1982.
3. Bioprocess Engineering Principles by Pauline M. Doran, Academic Press, 2011.
4. Biochemical Engineering Fundamentals by Bailey and Ollis, Mcgraw Hill, 2nd Edition, 2001.
5. Essentials of Process Control by Luyben and Luyben, McGraw-Hill Education, 2005.

Course outcome (Course Skill Set)
At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Identify and describe the basic characteristics of flow, pressure, and temperature transducers.	L1
CO2	Explain the dynamic behavior of first-order systems, including both mercury thermometers and single-tank systems, in response to step and pulse inputs.	L2
CO3	Apply knowledge of system interactions to analyze the response of interacting and non-interacting systems to step and pulse inputs.	L3
CO4	Evaluate the performance of temperature, pressure, and flow controllers in response to set point and load changes.	L4
CO5	Design experiments to investigate and optimize the characteristics of transducers and control systems, leading to innovative solutions for complex engineering problems.	L5

Program outcome of this course

Sl no	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
6	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	PO11

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	2											
CO2	2	3										
CO3		3		2								
CO4			3		2							
CO5			3								3	

BIOPROCESSING LAB			
Course Code	**MBBCL258B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:0	SEE Marks	50
Credits	1	Exam Hours	2

Course objectives:

- To teach students the techniques of inoculum development and biomass estimation in both shake flasks and fermenters.
- To provide hands-on experience in producing and estimating key bioproducts like citric acid and ethanol using different fermentation techniques.
- To introduce methods for the purification of intracellular products and the separation of bioproducts using various filtration and chromatography techniques.
- To equip students with skills in analyzing biomolecules through advanced techniques such as TLC, HPLC, and electrophoresis.
- To develop the ability to determine molecular weight and characterize proteins using techniques like SDS-PAGE and Western blotting.

Sl.NO	Experiments
1	Development of inoculum and biomass estimation (dry weight basis) in Shake flask studies
2	Preparation of the fermenter
3	Production and estimation of citric acid in both SSF and submerged fermentation
4	Production of ethanol/enzymes in fermenter- Study of product formation kinetics and substrate utilization
5	Production ethanol/enzyme by immobilized microbes
6	Purification of intracellular products through cell disruption techniques (homogenization /sonication)
7	Separation of biomass/product through tangential flow filtration (TFF)
8	Product enrichment operation through two phase aqueous extraction
9	Analysis of biomolecules through TLC/HPLC
10	Separation of Enzymes through gel and ion exchange chromatography
11	Molecular weight determination of protein by both native and SDS PAGE
12	Characterisation protein by western blotting

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Recall the procedures for inoculum development and biomass estimation in shake flask studies.
2. Understand the preparation and operation of fermenters, including the production and estimation of citric acid and ethanol.
3. Apply fermentation techniques using immobilized microbes and analyze the kinetics of product formation and substrate utilization.
4. Analyze the purification of intracellular products using cell disruption, filtration, and chromatography

techniques.

5. Critically evaluate and characterize proteins using advanced techniques such as SDS-PAGE and Western blotting.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Downstream Process Technology: A New Horizon In Biotechnology, Nooralabettu Krishna Prasad, PHI, 2012
2. Industrial Microbiology, Casida, Wiley, 1986
3. Biotechnology : A Text Book of Industrial Microbiology, T.D. Brock, Smaeur Associates, 1990
4. Comprehensive Biotechnology, Moo-Young, M., Bull, A. T., Dalton, H. Pergamon

Course outcome (Course Skill Set)
At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the procedures for inoculum development and biomass estimation in shake flask studies.	L1
CO2	Understand the preparation and operation of fermenters, including the production and estimation of citric acid and ethanol.	L2
CO3	Apply fermentation techniques using immobilized microbes and analyze the kinetics of product formation and substrate utilization.	L3
CO4	Analyze the purification of intracellular products using cell disruption, filtration, and chromatography techniques.	L4
CO5	Evaluate and characterize proteins using advanced techniques such as SDS-PAGE and Western blotting.	L5

Program outcome of this course

Sl no	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	2											
CO2	3	2										
CO3		2	3									
CO4				3	3							
CO5				3			2					

R PROGRAMMING FOR BIOLOGISTS LAB			
Course Code	**MBBCL258C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:0	SEE Marks	50
Credits	1	Exam Hours	2

Course objectives:

- To familiarize students with the basics of R programming, including installation, data input/output, and basic operations.
- To equip students with the skills to create various types of visualizations, ranging from basic plots to advanced 3D and ggplot visualizations.
- To reinforce students' understanding of basic and advanced statistical concepts, including regression analysis, ANOVA, and resampling methods.
- To introduce and apply multivariate statistical techniques such as PCA, discriminant analysis, cluster analysis, and MDS.
- To develop the ability to use R for solving complex engineering and scientific problems through data analysis and modeling.

Sl.NO	Experiments
1	Introduction: R installation, getting help
2	Data processing: input and output of data, examine data, basic grammar, array and matrix operations, basic functions
3	Visualizing data I: dot-plot, bar-plot, line-charts, box-plot
4	Visualizing data II & III: bag-plot, pie-charts, scatter-plot, pair-plot & polygon.
5	Visualizing data IV: 3-D plot, map, ggplot
6	Basic statistical knowledge review: mean, standard deviation, confidence interval, correlation coefficient
7	Simple linear regression.
8	Multiple linear regression & non-linear regression.
9	ANOVA.
10	Resampling (Jackknife and bootstrap)
11	Generalized linear model, Generalized additive model
12	Multivariate statistics I & II: PCA, & discriminant analysis
13	Multivariate statistics II & IV: Cluster analysis, MDS

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Students will be able to recall the basic steps of R installation, data input/output, and simple data processing commands.
2. Students will understand and apply basic R commands for data visualization, including creating dot-plots, bar-plots, and line charts.
3. Students will be able to apply R programming to create more complex visualizations like 3D plots, maps, and ggplots, and to perform basic statistical analyses.
4. Students will be able to analyze data using regression models (linear, multiple, and non-linear) and ANOVA, and interpret the results.
5. Students will critically evaluate and apply advanced statistical methods such as PCA, discriminant analysis, cluster analysis, and MDS to solve complex problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall

be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.
The duration of SEE is 03 hours

Suggested Learning Resources:

1. Crawley. 2005. Statistics: An Introduction using R. John Wiley & Sons, New York
2. Crawley. 2007. The R book. John Wiley & Sons, New York

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the basic steps of R installation, data input/output, and simple data processing commands.	L1
CO2	Apply basic R commands for data visualization, including creating dot-plots, bar-plots, and line charts.	L2
CO3	Apply R programming to create more complex visualizations like 3D plots, maps, and ggplots, and to perform basic statistical analyses	L3
CO4	Analyze data using regression models (linear, multiple, and non-linear) and ANOVA, and interpret the results.	L4
CO5	Critically evaluate and apply advanced statistical methods such as PCA, discriminant analysis, cluster analysis, and MDS to solve complex problems.	L5

Program outcome of this course

Sl no	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2	2	3										
CO3		3	2									
CO4				3	3							
CO5				3			3					

BIOSTATISTICS AND TOOL LAB			
Course Code	**MBBCL258D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:0	SEE Marks	50
Credits	1	Exam Hours	2

Course objectives:

- To provide a strong foundation in basic statistical principles, including data collection, analysis, and interpretation.
- To enable students to perform and interpret various statistical tests and apply them to real-world problems.
- To equip students with the skills to design, conduct, and analyze experiments using various statistical methods and designs.
- To train students in the use of statistical software like SPSS, Minitab, or other relevant tools for data analysis and experiment design.
- To foster the ability to use statistical methods and tools to solve complex engineering and scientific problems.

Sl.NO	Experiments
1	Measurement and Sampling: To select a simple random sample from the population and enter these data into SPSS/Minitab/or any other statistical software.
2	Diagrammatic & Graphical representation: To plot line diagrams, bar diagram. Pie chart, Histogram and frequency distribution of the collected data.
3	Summary Statistics: To calculate and interpret summary statistics for the data in your sample.
4	Correlation: Calculation & interpretation of correlation and regression between variables
5	Randomization: Use of open-source randomization tools and sample size estimation.
6	Hypothesis testing: To test a hypothesis by determining a significance difference for mean and proportion.
7	t – test: To use t- test for determining a significance difference between two groups.
8	Chi – Square test: Use of Chi – Square test of independent of Attributes for 2 X 2 contingency table.
9	Experimental Design: Design and analysis of experiments based on factorial design and calculate main effect, interaction effect.
10	Experimental Design: Design and analysis of mixture experiments using different factors.
11	Experimental Design: Design and analysis of screening experiments using Plackett–Burman designs
12	Experimental Design: Design and analysis of experiments based on response surface methodology (RSM).

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Students will be able to recall the basic concepts of measurement and sampling, including the selection of random samples and entry of data into statistical software.
2. Students will be able to understand and create diagrammatic and graphical representations such as line diagrams, bar diagrams, pie charts, and histograms.
3. Students will be able to apply summary statistics to calculate and interpret the collected data, and perform

correlation and regression analysis between variables.

4. Students will be able to analyze experimental data using various hypothesis tests like t-tests, Chi-square tests, and design experiments based on factorial, mixture, and screening designs.
5. Students will be able to critically evaluate and interpret the results of experiments, particularly those based on response surface methodology (RSM), to provide valid conclusions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Fundamentals Of Statistics (Paperback, SC GUPTA) Edition, 6; Publisher, Himalaya, 1984.
2. Design of Experiments 1st Edition Bradley Jones, Douglas C. Montgomery/
3. Fundamentals of Biostatistics Paperback – 1 December 2009 by V.B. Rastogi (Author).

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Students will be able to recall the basic concepts of measurement and sampling, including the selection of random samples and entry of data into statistical software.	L1
CO2	Students will be able to understand and create diagrammatic and graphical representations such as line diagrams, bar diagrams, pie charts, and histograms.	L2
CO3	Students will be able to apply summary statistics to calculate and interpret the collected data, and perform correlation and regression analysis between variables.	L3
CO4	Students will be able to analyze experimental data using various hypothesis tests like t-tests, Chi-square tests, and design experiments based on factorial, mixture, and screening designs.	L4
CO5	Students will be able to critically evaluate and interpret the results of experiments, particularly those based on response surface methodology (RSM), to provide valid conclusions.	L5

Program outcome of this course

Sl no	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	2											
CO2	2	3										
CO3		3	2									
CO4				3	2							
CO5				3			2					

BIOHAZARDS AND BIOSAFETY LAB			
Course Code	**MBBCL258E**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:0	SEE Marks	50
Credits	1	Exam Hours	2

Course objectives:

- To familiarize students with the design and layout of various biosafety levels (BSL1 to BSL4) and the specific safety measures required for each level.
- To enable students to prepare and implement SOPs for the safe handling and disposal of microorganisms and hazardous materials in laboratory settings.
- To emphasize the importance of personal protective equipment (PPE) and the responsible use of laboratory facilities to ensure a safe working environment.
- To teach students how to create and maintain essential safety documents, such as Safety Data Sheets (SDS), emergency procedures, and incident reports, ensuring compliance with regulatory standards.
- To equip students with the ability to assess and mitigate safety hazards in laboratory environments, particularly those associated with higher biosafety levels (BSL2, BSL3, BSL4).

Sl.NO	Experiments
1	Layout of Labs of BSL1, BSL2, BSL3 and BSL4
2	Prepare SOP for proper wearing, removal, and use of gloves, mouth mask, labwears
3	Safe and responsible use of microorganisms.
4	Safety hazards of BSL1, BSL2, BSL3 and BSL4 laboratory
5	Developing one page lab safety manual to highlight critically important issues of safety
6	Preparing student-signed safety agreements/safety quizes at the institution.
7	Handling blood borne pathogens
8	Preparation of laboratory manual specific to BSL1, BSL2, BSL3 and BSL4
9	Prepare, maintain, and post proper signage
10	Preparation of Document all injuries and spills
11	Making Safety Data Sheets (SDS)
12	Preparation of emergency procedures

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Recall the specific layout and safety requirements of BSL1, BSL2, BSL3, and BSL4 laboratories.
2. Explain the procedures for proper wearing, removal, and use of personal protective equipment (PPE) in laboratory settings.
3. Apply knowledge of biosafety protocols to develop and maintain laboratory safety manuals and safety data sheets (SDS).
4. Analyze the risks associated with handling blood-borne pathogens and microorganisms in BSL2 to BSL4

laboratories and propose appropriate safety measures.

5. Evaluate the effectiveness of emergency procedures and the accuracy of safety documentation, such as incident reports and safety agreements..

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marks is scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Guidelines for Biosafety in Teaching Laboratories, American Society for Microbiology, 2019
2. NIH/CDC: Biosafety in Microbiological and Biomedical Laboratories
3. NIH: Research Involving Recombinant or Synthetic Nucleic Acid Molecules
4. American Society for Microbiology (ASM):Biosafety in Teaching Laboratories

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Recall the specific layout and safety requirements of BSL1, BSL2, BSL3, and BSL4 laboratories.	L1
CO2	Explain the procedures for proper wearing, removal, and use of personal protective equipment (PPE) in laboratory settings.	L2
CO3	Apply knowledge of biosafety protocols to develop and maintain laboratory safety manuals and safety data sheets (SDS).	L3
CO4	Analyze the risks associated with handling blood-borne pathogens and microorganisms in BSL2 to BSL4 laboratories and propose appropriate safety measures.	L4
CO5	Evaluate the effectiveness of emergency procedures and the accuracy of safety documentation, such as incident reports and safety agreements.	L5

Program outcome of this course

Sl no	Description	PO
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	2											
CO2		2										
CO3			3									
CO4				3								
CO5					2							