BIOSTATISTICS AND DATA ANALYSIS			
Course Code	**1MBT101**	Scheme	2026
Type of Course	**PCC**	Semester	I
Teaching Hours/Week (L:T:P)	3: 0 :0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	**03**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course Objectives

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

1. CO1 (L2 – Understand): Explain the principles of biostatistics, probability, sampling, statistical distributions, and experimental design applicable to biological research.
2. CO2 (L3 – Apply): Apply appropriate descriptive and inferential statistical methods to biological and biomedical datasets.
3. CO3 (L4 – Analyze): Analyze biological data using hypothesis testing, ANOVA, correlation, regression, and non-parametric statistical methods.
4. CO4 (L4 – Analyze): Analyze and visualize biological datasets using statistical software and interpret statistical outputs appropriately.
5. CO5 (L5 – Evaluate): Evaluate statistical methods and experimental designs and draw scientifically valid conclusions from biological data.

Module-1

Fundamentals of Biostatistics and Biological Data

Introduction to biostatistics and its applications in biological, biomedical and life-science research; types and sources of biological data; qualitative and quantitative variables; discrete and continuous data; scales of measurement; population and sample; sampling methods; data organization and tabulation; frequency distributions; graphical representation of biological data; histograms, bar charts, box plots and scatter plots; measures of central tendency – mean, median and mode; measures of dispersion – range, variance, standard deviation and coefficient of variation; quartiles and percentiles; exploratory data analysis.

Number of Hours: 8

Module-2

Probability, Statistical Distributions and Estimation

Basic concepts of probability; probability rules; conditional probability and Bayes' theorem; random variables; discrete and continuous probability distributions; binomial, Poisson and normal distributions; standard normal distribution and z-scores; sampling distributions; Central Limit Theorem; standard error; confidence intervals; point and interval estimation; introduction to maximum likelihood estimation; resampling and bootstrap concepts.

Number of Hours: 8

Module-3

Hypothesis Testing and Experimental Design

Statistical hypotheses; null and alternative hypotheses; significance level and p-value; Type I and Type II errors; statistical power; one-sample and two-sample tests; paired and unpaired t-tests; chi-square test for goodness of fit and independence; one-way and two-way ANOVA; post-hoc tests; non-parametric tests – Mann–Whitney U, Wilcoxon signed-rank and Kruskal–Wallis tests; assumptions of statistical tests; experimental design in biological research; randomization, replication and blocking; controls and sources of experimental variation.

Number of Hours: 8

Module-4

Correlation, Regression and Multivariate Data Analysis

Covariance and correlation; Pearson and Spearman correlation; simple and multiple linear regression; regression coefficients and interpretation; coefficient of determination; residual analysis; introduction to logistic regression; analysis of covariance; Principal Component Analysis (PCA); clustering methods; hierarchical clustering; heatmaps; dimensionality reduction; multivariate analysis of biological datasets.

Number of Hours: 9

Module-5

Advanced Biological Data Analysis

Exploratory data analysis; data normalization and transformation; missing data and outlier detection; effect size and confidence intervals; multiple comparisons; False Discovery Rate (FDR); analysis of gene-expression datasets; introduction to omics data analysis; biological data visualization; introduction to survival analysis; ROC curves and diagnostic test evaluation; selection of appropriate statistical tests; reproducible statistical analysis; interpretation and reporting of statistical results.

Number of Hours: 9

Textbooks

1. Motulsky, H., Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking, 4th Edition, Oxford University Press.
2. Pagano, M. and Gauvreau, K., Principles of Biostatistics, 2nd Edition, CRC Press.
3. Rosner, B., Fundamentals of Biostatistics, 8th Edition, Cengage Learning.

Reference Books

1. Zar, J. H., Biostatistical Analysis, 5th Edition, Pearson.
2. Daniel, W. W. and Cross, C. L., Biostatistics: A Foundation for Analysis in the Health Sciences, 11th Edition, Wiley.
3. Kirkwood, B. R. and Sterne, J. A. C., Essential Medical Statistics, 2nd Edition, Wiley-Blackwell.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Biomolecular Structure and Biophysics			
Course Code	**1MBT102**	Scheme	2026
Type of Course	**PCC**	Semester	I
Teaching Hours/Week (L:T:P)	3: 0 :0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	**03**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course Objectives

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

1. CO1 (L2 – Understand): Explain the structural organization of biomolecules and the physicochemical principles governing their stability and function.
2. CO2 (L3 – Apply): Apply thermodynamic and kinetic principles to analyzebiomolecular interactions and biological processes.
3. CO3 (L3 – Apply): Interpret three-dimensional structures of proteins and nucleic acids using structural biology techniques and computational tools.
4. CO4 (L4 – Analyze): Analyzebiomolecular dynamics, membrane transport, and molecular recognition using biophysical principles and experimental methods.
5. CO5 (L5 – Evaluate): Evaluate advanced biophysical techniques and their applications in biomedical engineering, drug discovery, and biomolecular research.

Module-1

Structure and Organization of Biomolecules: Water and non-covalent interactions in biomolecular organization. Structure and properties of amino acids; peptide bond; protein structural hierarchy (primary to quaternary); motifs and domains. Structure of nucleic acids: DNA & RNA structure, DNA conformations (A, B, Z), RNA structural motifs, chromatin organization. Structure and biological roles of carbohydrates, glycoconjugates,lipids, and biological membranes.
Number of Hours: 08

Module-2

Bioenergetics and Metabolism
Bioenergetics and the laws of thermodynamics in biological systems; Gibbs free energy, enthalpy, entropy, redox reactions and biological oxidation; ATP as the energy currency of the cell; high-energy phosphate compounds; electron transport chain, oxidative phosphorylation and chemiosmotic theory; mitochondrial bioenergetics and regulation of ATP synthesis. Carbohydrate metabolism: Glycolysis, gluconeogenesis, pentose phosphate pathway, glycogen metabolism and regulation. Citric acid (TCA) cycle and its amphibolic role. Lipid metabolism: β-oxidation of fatty acids, fatty acid biosynthesis, ketone body metabolism and regulation. Amino acid metabolism: transamination, oxidative deamination, urea cycle and metabolic integration.

Module-3

Biomolecular Folding and Stability: Protein folding pathways and energy landscapes, Levinthal paradox, molecular chaperones and protein turnover, protein stability and denaturation, protein–protein, protein–DNA and protein–RNA interactions, allosteric and cooperative binding
Biomolecular Dynamics: Thermodynamics of biomolecular interactions Binding kinetics and molecular recognition transport mechanisms- Diffusion ,ion channels and transporters Membrane biophysics and ion transport, membrane potential and electrophysiology, patch-clamp techniques and applications, cell signaling pathways (GPCRs, receptor tyrosine kinases, second messenger systems, calcium signaling),,
Number of Hours: 08

Module-4

Principles of X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectroscopy, Cryo-Electron Microscopy (Cryo-EM), Small-Angle X-ray Scattering (SAXS), Circular Dichroism (CD) spectroscopy, UV-Visible, Fluorescence and Raman spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, Mass spectrometry for protein characterization, Surface Plasmon Resonance (SPR), Isothermal Titration Calorimetry (ITC), Differential Scanning Calorimetry (DSC), Dynamic Light Scattering (DLS), Atomic Force Microscopy (AFM), Number of Hours: 09

Module-5

Advanced Biophysics and Biomedical Applications (9 Hours) Single-molecule biophysics, single-molecule fluorescence microscopy, Förster Resonance Energy Transfer (FRET), Fluorescence Recovery After Photobleaching (FRAP), Fluorescence Correlation Spectroscopy (FCS), optical and magnetic tweezers, structural basis of disease and protein misfolding, biophysics of membrane proteins and ion channels, AI-assisted structural biology (AlphaFold, RoseTTAFold), systems and synthetic biology, structure-based drug discovery, nanobiophysics, and emerging applications in precision medicine and biomedical engineering.

Number of Hours:09

Textbooks

1. Nelson, D.L. and Cox, M.M., Lehninger Principles of Biochemistry, 8th Edition, W.H. Freeman.

Branden, C. and Tooze, J.,

2. Introduction to Protein Structure, 2nd Edition, Garland Science.

Tinoco, I., Sauer, K., Wang, J.C. and Puglisi, J.D.,

3. Physical Chemistry: Principles and Applications in Biological Sciences, 5th Edition, Pearson.

Reference Books / Manuals

1. Cantor, C.R. and Schimmel, P.R., Biophysical Chemistry, Volumes I–III, W.H. Freeman.
2. Voet, D. and Voet, J.G., Biochemistry, 5th Edition, Wiley.
3. Nelson, P., Biological Physics: Energy, Information, Life, Updated Edition, W.H. Freeman.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Advanced Microbiology

Course Code	**1MBT103**	Scheme	2026
Type of Course	**PCC**	Semester	I
Teaching Hours/Week (L:T:P)	3: 0 :0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0:48	SEE Marks	50
Credits	**03**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course Objectives

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

6. CO1 (L2 – Understand): Explain the principles of microbial diversity, physiology, genetics, cultivation methods, and advanced microbiological techniques.
7. CO2 (L3 – Apply): Apply concepts of cellular and molecular microbiology to understand microbial communication, biofilm formation, host–pathogen interactions, and antimicrobial resistance.
8. CO3 (L4 – Analyze): Analyze the composition, function, and therapeutic significance of the human microbiome and microbial communities using modern omics approaches.
9. CO4 (L4 – Analyze): Analyze the role of microorganisms in food, dairy, pharmaceutical, and industrial applications, including quality assurance, food safety, and regulatory practices.
10. CO5 (L5 – Evaluate): Evaluate emerging technologies such as synthetic biology, CRISPR, microbial engineering, omics, artificial intelligence, and precision microbiology for biomedical and industrial applications.

Module-1

Fundamentals of Advanced Microbiology

Microbial diversity and taxonomy; microbial cell structure and ultrastructure; microbial physiology and metabolism; microbial growth kinetics and regulation; microbial genetics and genome organization; microbial cultivation, isolation and preservation techniques; microscopy and advanced microbiological techniques

Number of Hours: 08

Module-2

Cellular Microbiology

Microbial cell architecture and compartmentalization; cell division and microbial cytoskeleton; microbial signal transduction and quorum sensing; secretion systems; microbial adhesion, motility and chemotaxis; biofilm formation and regulation; microbial stress responses; molecular mechanisms of host–pathogen interactions; virulence factors, toxins and antimicrobial resistance; microbial gene regulation and molecular adaptation. Number of Hours: 08

Module-3

Human Microbiome

Human microbiome and microbial ecology; composition and functions of the gut, oral, skin, respiratory and urogenital microbiomes; microbiome–host interactions; microbiome in health and disease; dysbiosis and immune modulation; microbiome analysis using metagenomics, metatranscriptomics, metaproteomics and metabolomics; microbial metabolites and host signaling; microbiota–host communication through the gut–brain, gut–lung, gut–liver, gut–kidney and gut–skin axes; role of the microbiome in metabolic, neurological, autoimmune and cardiovascular disorders

Number of Hours: 08

Module-4

Antimicrobial Resistance and Microbial Therapeutics

Antimicrobial agents and mechanisms of action; intrinsic and acquired antimicrobial resistance; mechanisms of resistance including enzymatic inactivation, target modification, efflux pumps and reduced permeability; MDR, XDR and PDR pathogens; horizontal gene transfer; antimicrobial susceptibility testing; antimicrobial stewardship and the One Health approach. Antimicrobial peptides (AMPs), bacteriocins and phage therapy; microbiome engineering, fecal microbiota transplantation (FMT), live biotherapeutic products and personalized microbiome-based medicine for combating antimicrobial resistance.

Number of Hours: 09

Module-5

Food, Dairy and Industrial Microbiology

Food and dairy microorganisms; starter cultures and probiotics; microbial fermentation of dairy, cereal, meat and beverage products; food spoilage microorganisms and foodborne pathogens; food preservation and quality assurance; industrial production of enzymes, antibiotics, vitamins, organic acids and bioactive metabolites; pharmaceutical microbiology, sterility assurance, biosafety, GMP, HACCP and regulatory aspects.

Number of Hours: 09
Textbooks 1. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M. and Stahl, D.A., Brock Biology of Microorganisms, 16th Edition, Pearson, 2021. 2. Moat, A.G., Foster, J.W. and Spector, M.P., Microbial Physiology, 4th Edition, Wiley-Liss, 2002. 3. Schaechter, M., Schaechter's Mechanisms of Microbial Disease, 6th Edition, Wolters Kluwer, 2020. Reference Books / Manuals 1. Baltz, R.H., Demain, A.L. and Davies, J.E. (Eds.), Manual of Industrial Microbiology and Biotechnology, 4th Edition, ASM Press, 2018. 2. Murray, P.R., Rosenthal, K.S. and Pfaller, M.A., Medical Microbiology, 10th Edition, Elsevier, 2024. 3. Tannock, G.W. (Ed.), The Human Microbiota and Microbiome, Caister Academic Press, 2022. Additional References (Recommended) 1. Prescott, L.M., Harley, J.P. and Klein, D.A., Prescott's Microbiology, 12th Edition, McGraw-Hill. 2. Willey, J.M., Sherwood, L.M. and Woolverton, C.J., Prescott's Microbiology, 12th Edition, McGraw-Hill. **3.** ASM Press, Manual of Clinical Microbiology, 13th Edition.
Assessment Structure (both CIE and SEE) The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together. **Continuous Internal Evaluation:** **Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]** A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA. In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

INDUSTRIAL ENGINEERING +LAB			
Course Code	1MBT104A	Scheme	2026

Type of course	**IPCC**	Semester	I
Teaching Hours/Week (L:T:P)	3:0:2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0 : 28 : 48 :	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	03

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:
CO1 (L2 – Understand): Explain the principles of bioprocess engineering, microbial growth kinetics, and transport phenomena relevant to biological systems.
CO2 (L3 – Apply): Apply engineering principles to the design and operation of bioreactors and fermentation systems.
CO3 (L4 – Analyze): Analyze upstream and downstream bioprocesses for the production and purification of biological products.
CO4 (L4 – Analyze): Analyze process parameters, monitoring strategies, and scale-up considerations for industrial bioprocesses.
CO5 (L5 – Evaluate): Evaluate bioprocesses using modern analytical techniques and laboratory practices for biomedical, pharmaceutical, and industrial applications.

Module-1

Advanced Bioprocess Fundamentals

Bioprocess development pipeline; microbial, animal and stem cell culture systems; structured and unstructured growth kinetics; metabolic flux concepts; enzyme kinetics in bioprocesses; transport phenomena (heat, mass and momentum transfer); media optimization using Design of Experiments (DoE); sterilization and contamination control.

Number of Hours:08

Module-2

Advanced Bioreactor Engineering (8 Hours)

Bioreactor design principles; stirred-tank, airlift, packed-bed, fluidized-bed, membrane and perfusion bioreactors; single-use bioreactors; oxygen transfer and mixing; shear effects; immobilized cell and enzyme reactors; bioreactor instrumentation; advanced sensors, Process Analytical Technology (PAT), process control and automation.

Number of Hours:08

Module-3

Advanced Upstream and Downstream Processing

Cell line development; inoculum optimization; fed-batch and continuous bioprocessing; perfusion culture; clarification; filtration; centrifugation; membrane separations; chromatography (affinity, ion exchange, size exclusion); viral clearance; formulation; Quality by Design (QbD); GMP and validation.

Number of Hours:08

Module-4

Bioprocess Modeling, Scale-Up and Digital Biomanufacturing

Bioprocess modeling and simulation; bioreactor scale-up and scale-down; Computational Fluid Dynamics (CFD); oxygen transfer coefficient (kLa); mixing time analysis; process optimization; digital twins; soft sensors; AI and machine learning in bioprocessing; process economics and sustainability.

Number of Hours: 09

Module-5

Emerging Bioprocess Technologies and Laboratory Applications

Bioprocessing for monoclonal antibodies, vaccines, recombinant proteins, gene and cell therapies; stem cell bioprocessing; tissue engineering bioreactors; organ-on-chip and microfluidic bioprocesses; synthetic biology; continuous manufacturing; regulatory compliance (FDA, EMA, ICH); laboratory applications in bioreactor operation, PAT, chromatography, cell viability analysis, and process data analytics.

Number of Hours: 09

PRACTICAL COMPONENTS OF IPCC

List of experiments

1. Preparation, sterilization and optimization of fermentation media.
2. Batch cultivation of microorganisms and determination of growth kinetics.
3. Estimation of biomass concentration by optical density and dry cell weight methods.
4. Operation and performance evaluation of a laboratory-scale stirred tank bioreactor (pH, DO, temperature and agitation control).
5. Determination of oxygen transfer coefficient (kLa) and mixing characteristics in a bioreactor.
6. Enzyme production through microbial fermentation and enzyme activity assay.
7. Cell disruption techniques and recovery of intracellular products.
8. Downstream processing: centrifugation, membrane filtration and ultrafiltration.
9. Purification of biomolecules using chromatography (ion-exchange/gel filtration/affinity) and analysis of purity.
10. Process monitoring and data acquisition using bioprocess instrumentation and sensors.
11. Bioprocess modeling and simulation using MATLAB/SuperPro Designer/BioSolve or equivalent software.
12. Mini project involving design, optimization and techno-economic analysis of a bioprocess.

Textbooks

1. Shuler, M.L. and Kargi, F., Bioprocess Engineering: Basic Concepts, 3rd Edition, Pearson Education, 2017.
2. Doran, P.M., Bioprocess Engineering Principles, 2nd Edition, Academic Press (Elsevier), 2013.
3. Nielsen, J., Villadsen, J. and Lidén, G., Bioreaction Engineering Principles, 3rd Edition, Springer, 2017.

Reference Books / Manuals

1. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, 2nd Edition, McGraw-Hill, 1986.
2. Stanbury, P.F., Whitaker, A. and Hall, S.J., Principles of Fermentation Technology, 3rd Edition, Elsevier, 2017.
3. Crueger, W. and Crueger, A., Biotechnology: A Textbook of Industrial Microbiology, 3rd Edition, Panima Publishing, 2000.

Additional References (Optional)

1. Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, 3rd Edition, Wiley, 2018.
2. Lydersen, B.K., D'Elia, N.A. and Nelson, K.L. (Eds.), Bioprocess Engineering: Systems, Equipment and Facilities, CRC Press.
3. Aiba, S., Humphrey, A.E. and Millis, N.F., Biochemical Engineering, University of Tokyo Press.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

DAIRY AND PROBIOTIC BIOTECHNOLOGY WITH LABORATORY			
Course Code	1MBT104B	Scheme	2026
Type of course	**IPCC**	Semester	1
Teaching Hours/Week (L:T:P)	3: 0 : 2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42: 0: 28 : 48	SEE Marks	50

Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course outcome (Course Skill Set)

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

1. **Understand** the composition, microbiology, and biochemical properties of milk and dairy products.
2. **Apply**principles of dairy biotechnology for the production and quality evaluation of fermented dairy products.
3. **Explain** the characteristics and functional applications of probiotics, prebiotics, synbiotics, and postbiotics.
4. **Evaluate**the role of microbial cultures and biotechnological processes in developing functional dairy foods.
5. **Perform** laboratory techniques for isolation, identification, enumeration, and evaluation of probiotic microorganisms and dairy products.

Module-1

DAIRY MICROBIOLOGY AND BIOTECHNOLOGY: Composition and nutritional properties of milk; physicochemical properties of milk; milk microbiota and sources of microbial contamination; beneficial and harmful microorganisms associated with milk; microbial growth in milk; starter cultures and their characteristics; lactic acid bacteria (LAB) and their industrial importance; dairy biotechnology and applications of microbial cultures in dairy processing; preservation and quality aspects of milk.

Number of Hours: 8

Module-2

FERMENTED DAIRY PRODUCTS AND DAIRY BIOPROCESSING: Principles of dairy fermentation; metabolism of lactose and production of lactic acid; starter cultures and their selection, maintenance, and propagation; manufacture and microbiology of fermented dairy products—yogurt, cultured buttermilk, kefir, sour cream, and fermented milk products; cheese production—principles, starter cultures, ripening, and biochemical changes; microbial defects and quality control of fermented dairy products.

Number of Hours: 8

Module-3

PROBIOTICS, PREBIOTICS AND SYNBIOTICS: Definition, history, and characteristics of probiotics; criteria for selection of probiotic microorganisms; important probiotic genera and species; mechanisms of probiotic action; health benefits and functional properties of probiotics; prebiotics and their sources; synbiotics and their classification; probiotic foods and beverages; probiotic dairy products; factors affecting probiotic viability and stability during processing and storage.

Number of Hours: 8

Module-4

ADVANCED PROBIOTIC AND DAIRY BIOTECHNOLOGY: Microencapsulation and immobilization of probiotic microorganisms; methods for improving probiotic survival and stability; postbiotics—definition, classification, production, and health benefits; microbial metabolites and bioactive compounds; bacteriocins and their applications in dairy and food preservation; functional foods and nutraceuticals; development of novel probiotic and synbiotic dairy products; emerging trends in dairy biotechnology.

Number of Hours: 8

Module-5

QUALITY, SAFETY AND APPLICATIONS OF DAIRY AND PROBIOTIC PRODUCTS: Quality assessment of milk and dairy products; microbiological, physicochemical, and sensory evaluation; viability and enumeration of probiotic cultures; stability and shelf-life of probiotic products; food safety and regulatory aspects of probiotic foods; challenges in commercialization of probiotic products; functional dairy foods and personalized nutrition; applications of omics, genomics, metabolomics, and bioinformatics in dairy and probiotic biotechnology; future perspectives and industrial applications.

Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

List of experiments

1. Determination of physicochemical properties and quality parameters of milk.
2. Microbiological analysis and total viable count of milk and dairy products.
3. Isolation and identification of lactic acid bacteria from fermented dairy products.
4. Characterization of isolated probiotic microorganisms using biochemical tests.

5. Enumeration of probiotic bacteria in commercial and laboratory-prepared probiotic products.
6. Preparation of yogurt using selected starter cultures and evaluation of quality parameters.
7. Preparation of fermented milk products using probiotic cultures.
8. Evaluation of probiotic viability during storage under different conditions.
9. Study of antimicrobial activity of probiotic cultures against selected foodborne pathogens.
10. Preparation and evaluation of a synbiotic dairy product.
11. Microencapsulation of probiotic bacteria and evaluation of encapsulation efficiency.
12. Demonstration of postbiotic production and analysis of selected bioactive metabolites.
13. Sensory evaluation and shelf-life assessment of probiotic dairy products.
14. **Demonstration experiment:** Molecular identification of probiotic isolates using PCR-based methods.

Textbooks:

1. Walstra, P., Wouters, J. T. M. and Geurts, T. J. **Dairy Science and Technology**. 2nd Edition, CRC Press.
2. Tamime, A. Y. and Robinson, R. K. **Yogurt: Science and Technology.** 3rd Edition, Woodhead Publishing.
3. Chandan, R. C. and Kilara, A. **Dairy Processing and Quality Assurance.** Wiley-Blackwell.
4. Gänzle, M. G. **Lactic Acid Bacteria as Protective Cultures in Food Fermentation**. Academic/Scientific Reference.
5. Shah, N. P. **Probiotic Bacteria: Selective Enumeration and Survival in Dairy Foods.** CRC Press.

Reference books / Manuals:

1. Fox, P. F., Guinee, T. P., Cogan, T. M. and McSweeney, P. L. H. **Fundamentals of Cheese Science.** 2nd Edition, Springer.
2. McSweeney, P. L. H. and Fox, P. F. **Advanced Dairy Chemistry**. Springer.
3. Fuller, R. **Probiotics: The Scientific Basis.** Chapman & Hall.

Web links and Video Lectures (e-Resources):

- https://www.fao.org/food-safety/en/
- https://www.fssai.gov.in/
- https://www.who.int/health-topics/food-safety
- https://www.ncbi.nlm.nih.gov/
- https://www.cdc.gov/food-safety/
- https://www.nptel.ac.in/
- https://www.coursera.org/

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12marks in the CIE Practical component.

Table – ICs/IPCCs 1Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

PROGRAMMING FOR BIOLOGISTS+LAB			
Course Code	1 MBT104C	Scheme	2026
Type of course	**IPCC**	Semester	1
Teaching Hours/Week (L:T:P)	3: 0 : 2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42: 0: 28 : 48	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 (L2 – Understand): Explain fundamental programming concepts, computational thinking, and the role of programming in biological and life-science research.
2. CO2 (L3 – Apply): Apply Python and R programming concepts to process, manipulate, and analyze biological data.
3. CO3 (L3 – Apply): Develop programs for biological sequence analysis, data processing, statistical analysis, and visualization using appropriate programming libraries and packages.
4. CO4 (L4 – Analyze): Analyze biological datasets using Python, R, Biopython, and Bioconductor and interpret computational results.
5. CO5 (L5 – Evaluate): Design and evaluate computational workflows for biological problems, integrating programming, statistical analysis, visualization, and reproducible data analysis.

Module-1

Fundamentals of Programming for Biologists

Introduction to computational biology and programming; role of programming in modern biological research; overview and comparison of Python and R; programming environments including Jupyter Notebook, Google Colab and RStudio; variables, constants, data types, operators and expressions; input and output; basic data structures; conditional and iterative programming concepts; functions and modular programming; files and biological data formats; introduction to biological datasets including DNA, RNA, protein sequences and tabular data; basic principles of data organization, reproducibility, debugging and documentation.

Number of Hours: 8.

Module-2

Python Programming for Biological Applications

Python syntax and programming fundamentals; variables and data types; strings, lists, tuples, sets and dictionaries; conditional statements and loops; functions and modules; file handling; reading and writing CSV, TSV and FASTA files; string manipulation and regular expressions; exception handling and debugging; NumPy for numerical computation; Pandas for biological data manipulation; Matplotlib for visualization; basic statistical analysis using Python.

Number of Hours: 8

Module-3

Python for Bioinformatics and Biological Data Analysis

Introduction to Biopython; biological sequence objects; DNA and RNA sequence manipulation; transcription and translation; nucleotide composition and GC content; sequence searching and motif identification; restriction-site analysis; FASTA sequence processing; pairwise sequence alignment; multiple sequence alignment concepts; BLAST and biological databases; protein sequence analysis; phylogenetic analysis; biological data visualization; development of simple Python-based bioinformatics workflows.

Number of Hours: 8

Module-4

R Programming and Statistical Analysis for Biologists

Introduction to R and RStudio; R objects and data types; vectors, matrices, lists and data frames; factors; operators and expressions; conditional statements and loops; functions; importing and exporting biological datasets; data cleaning and transformation; descriptive statistics; probability distributions; hypothesis testing; t-test; chi-square test; ANOVA; correlation and regression analysis; basic biological data visualization using R.

Number of Hours: 9

Module-5

Biological Data Visualization and Advanced Analysis Using R

Data visualization using ggplot2; bar plots, box plots, scatter plots, histograms and line plots; heatmaps; correlation plots; clustering; Principal Component Analysis (PCA); analysis and visualization of gene-expression datasets; introduction to Bioconductor; biological databases and annotation packages; reproducible biological data analysis; integration of Python and R workflows; interpretation and reporting of computational results.

Number of Hours: 9

PRACTICAL COMPONENTS OF IPCC

List of experiments

1. Introduction to Python and R Programming Environments using Jupyter Notebook, Google Colab and RStudio
2. Basic Programming in Python and R: Data Types, Variables, Operators and Control Structures
3. DNA/RNA Sequence Manipulation and GC Content Analysis using Python
4. DNA Transcription, RNA Translation, Codon Analysis and Restriction Site Identification
5. Reading and Processing Biological Data Files (FASTA, CSV and TSV) using Python
6. Biological Data Manipulation and Statistical Analysis using NumPy and Pandas
7. Biological Data Visualization using Matplotlib and Seaborn
8. Sequence Analysis and Pairwise Sequence Alignment using Biopython
9. Data Structure Manipulation and Analysis in R
10. Import, Cleaning and Analysis of Biological Datasets using R
11. Statistical Analysis of Biological Data using R (Descriptive Statistics, t-test, Chi-square Test and ANOVA)
12. Correlation and Regression Analysis of Biological Data using R
13. Publication-Quality Biological Data Visualization using ggplot2
14. Principal Component Analysis (PCA), Clustering and Heatmap Analysis of Biological Datasets
15. Gene Expression Data Analysis using R/Bioconductor
16. Mini Project: Development of an Integrated Python–R Workflow for Biological Data Analysis and Visualization

Textbooks

1. Downey, A. B., Think Python: How to Think Like a Computer Scientist, 3rd Edition, O'Reilly Media.
2. Wickham, H. and Grolemund, G., R for Data Science, 2nd Edition, O'Reilly Media.
3. Jones, M. P., Python for Biologists, Self-published / online resource.

Reference Books

1. Cock, P. J. A. et al., Biopython: Freely Available Python Tools for Computational Molecular Biology and Bioinformatics, Bioinformatics.
2. Wickham, H., Çetinkaya-Rundel, M. and Grolemund, G., R for Data Science, 2nd Edition, O'Reilly Media.
3. Gentleman, R. et al., Bioconductor: Open Software Development for Computational Biology and Bioinformatics, Genome Biology.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12marks in the CIE Practical component.

Table – ICs/IPCCs 1Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Food Process Engineering +Lab			
Course Code	1MBT104D	Scheme	2026
Type of course	**IPCC**	Semester	1
Teaching Hours/Week (L:T:P)	3: 0 :2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	42:0:28:48	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab- CIE only.	Exam Hours	3

Course outcome (Course Skill Set)

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

11. Understand food properties and food processing at ambient temperature.
12. Apply food processing methods at ambient temperature.
13. Apply and analyze heat removal methods for food processing.
14. Understand heat processing for food applications.
15. Apply and evaluate heat application methods for food processing.

Module-1

Properties of Foods & Food Processing at ambient temperature I

Properties of Foods: Composition, Physical, Rheological and biochemical properties, Sensory characteristics, Nutritional quality Food Processing at ambient-temperature: Raw Food Processing- Cooling crops and carcasses; Cleaning- wet and dry cleaning; Sorting and grading- shape and size sorting, weight sorting, colour and machine vision sorting and grading; Peeling Reduction of Size- Solid foods- Theory, equipment, developments in size reduction technology, effects on foods and microbes; Liquid foods-Theory, emulsifying agents and stabilizers, equipment, effect on foods and microbes.

Number of Hours: 8

Module-2

Food Processing at ambient temperature II

Mixing and Forming- Mixing-Theories of solids and liquids mixing, equipment, effect on foods and microorganisms; Forming- Bread moulders, pie, tart and biscuit formers, confectionery moulders and depositors Separation and Concentration of components of Food: Theory and equipment for Centrifugation, Filtration and Expression; Solvent Extraction- Theory, solvents, supercritical CO2, Equipment; Membrane concentration- theory, equipment and applications, types of membrane system, effect on foods and microorganism

Number of Hours: 8

Module-3

Food processing by heat removal

Chilling and modified atmospheres- theory-refrigeration, modified atmospheres; equipment- mechanical refrigerators, cryogenic chilling, cold storage, temperature monitoring, modified and controlled atmospheric storage; applications- fresh and processed foods; effects on sensory and nutritional qualities of foods &microbesFreezing- theory- ice crystal formation, solute concentration, freezing time calculation, thawing; equipment- mechanical freezers, cryogenic freezers, new developments in freezing, frozen storage, thawing; effect on foods- freezing, frozen storage and thawing; effect on microbesFreeze drying- Theory, equipment and effect on foods and microbes; Freeze concentration- Theory, equipment and effect on foods and microbes

Number of Hours: 8

Module-4

Food Processing by heat application

Heat Processing – Theory- Thermal properties of foods, heat transfer; Heat sources and application methods- direct and indirect heating methods, energy use and methods to reduce energy consumption, types of heat exchangers; Effect of heat on microbes, enzymes, nutritional and sensory characteristics of food

Number of Hours: 8

Module-5

Food Processing by heat application

Processing by heat using steam or water: Blanching- Theory, Equipment- steam blanchers, hot water blanchers, new blanching methods, effect on food and microbes; Pasteurization- Theory, Equipment- pasteurization of packaged and unpackaged foods, effect on foods; Sterilization by heat- In container sterilization- theory, retorting, equipment, Ultra high temperature (UHT)/aseptic processes- theory, processing, equipment, effect on foodcanning, UHT processing; Evaporation- theory, improvement of evaporation economics, equipment, effect on foods and microbes; Distillation- theory, equipment, effect on foods and microbes; Extrusion- theory of extrusion cooking- ingredient properties, operating characteristics of extruder; equipment- single and twin screw extruders, control of extruders; food applications- confectionery, cereal and protein based products; effects on sensory characteristics and nutritional value of foods & microorganisms

Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

List of experiments

1. Measuring different physical properties of foods
2. Milling operations
3. Batch sedimentation
4. Solvent extraction.
5. Rotary vacuum evaporation
6. Blanching operations
7. Pasteurization of juice
8. Freeze drying operations
9. Drying experiment using hot air oven (Demonstration Experiments For CIE)
10. Sterilization of food material (Demonstration Experiments For CIE)

Textbooks:

1. Food processing technology - principles and practice. P.J. Fellows, CRC press, 3rd edition, 2009
2. Introduction to Food Engineering. R Paul Singh & Dennis R Heldman, Amsterdam Elsevier/Academic Press, 4th Edition, 2009
3. Fundamentals of food engineering. D.G. Rao, PHI Leraning Private Limited, New Delhi, 2010

Reference books / Manuals:

4. Food process engineering and technology. Zeki Berk, 1st edition, 2009, CRC Press, New York
5. Trends in Food Engineering. Jorge E. Lozano, Cristina Anon, Gustavo V. Barbosa-Canovas, Efren Parada-Arias, CRC Press; 1st Edition, 2000
6. Novel Food Processing Technologies (Food Science and Technology Series). Gustavo V. Barbosa-Canovas, Maria S. Tapia, M. Soledad Tapia, M. Pilar Cano, Publisher: CRC Press, 1st Edition, 2004

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/126/105/126105011/
2. https://archive.nptel.ac.in/courses/126/105/126105015/
3. https://onlinecourses.nptel.ac.in/noc22_ag03/preview
4. https://onlinecourses.nptel.ac.in/noc19_ag02/preview
5. https://onlinecourses.nptel.ac.in/noc22_ch53/preview
6. https://nptel.ac.in/courses/126105011
7. https://www.youtube.com/watch?v=_U1PBYkuSVk

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12marks in the CIE Practical component.

Table – ICs/IPCCs 1Distribution of marks corresponding to laboratory component

Component	**Description**	**Marks**
	Allotment of marks for regular classwork	
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
	Allotment of marks for CIE practical test	
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Food Packaging and Storage Engineering			
Course Code	1MBT105A	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0: 48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

1. Learn about packaging materials, packaging systems and food storage
2. Apply his understanding to select appropriate packaging.
3. Learn to evaluate suitability of appropriate storage system.
4. Evaluate bio- films for various food packaging.
5. Learn how to test materials for their suitability for packaging.

Module-1

INTRODUCTION:

Function of packaging, marketing consideration for a package and types of packaging. Barrier properties of packaging material, gas permeation rates- oxygen transmission rate (OTR), water vapour transmission rate (WVTR), bursting strength, tensile strength, tearing strength, drop test, puncture test, etc

Number of Hours: 8

Module-2

PACKAGING MATERIALS:

Selection of packaging materials, packaging machines and labeling Packaging materials for foods, Selection criteria of packaging materials for raw and processed food products. Machinery for Packaging: Form fill and seal machines, vacuum packaging machine, shrink wrap packaging machine and multilayer packaging system. Package labeling: functions, nutrition labeling, ingredient characterization handling instruction, and regulations; Shelf life of packaged food: water activity and prediction of shelf life. Packaging logistics.

Number of Hours: 8

Module-3

STORAGE ENGINEERING-I: FOOD STORAGE:

Importance of scientific storage systems, postharvest Physiology of semi-perishables and perishables, climacteric and non-climacteric fruits, respiration, ripening, changes during ripening, ethylene biosynthesis. Product damages during storage. Storage structures: Traditional, improved and modern storage. Structures: farm silos. Stored grain management and aeration: moisture and temperature changes in stored grains; conditioning of environment inside. Storage, purposes of aeration, aeration theory and aeration system operation.

Number of Hours: 8

Module-4

STORAGE ENGINEERING-II:

Storage pests and control: Damage due to storage insects, pests, rodents and its control. Storage of perishables: cold storage, controlled and modified atmospheric storage, hypoboric storage, evaporative cooling storage, conditions for storage of perishable products, control of temperature and relative humidity inside perishable storage.

Number of Hours: 8

Module-5

BIODEGRADABLE PACKAGING:

Types of packaging, classification, advantages and limitations of each type of packaging, economics of various packaging materials; Specifications for packaging various food products, testing standards, testing agencies and biodegradability; Types of natural polymers used for developing food packaging, properties of natural polymers for food packaging applications, chemical modifications of natural polymers for food applications; Methods of manufacturing biodegradable packaging, testing and evaluation; Synthetic biopolymers used for packaging applications. Properties of the polymers and specifications; Methods of manufacturing synthetic polymer films, testing and evaluation.

Number of Hours: 8

Textbooks:

1. Food Packaging: Principles and Practice. Gordon L. Robertson, CRC Press, 2012.
2. Coles, R., McDowell, D., & Kirwan, M. J. (Eds.). **Food Packaging Technology**. Blackwell Publishing Ltd., 2003.
3. Rahman, M. S. (Ed.). **Handbook of Food Preservation**. 2nd Edition, CRC Press, 2007.
4. Kader, A. A. **Postharvest Technology of Horticultural Crops**. 3rd Edition, University of California, Agriculture and Natural Resources, 2002.

Reference books / Manuals:

1. Hand book of **Postharvest Technology**: Cereals, CRC Press, 2003.
2. Han, J. H. (Ed.). **Innovations in Food Packaging.** 2nd Edition, Academic Press (Elsevier), 2014.
3. Emblem, A., & Emblem, H. **Packaging Technology: Fundamentals, Materials and Processes**. Woodhead Publishing, 2012.
4. Sun, D.-W. (Ed.). **Handbook of Frozen Food Processing and Packaging.** 2nd Edition, CRC Press, 2011.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

VACCINE DESIGN AND DEVELOPMENT			
Course Code	1MBT105B	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0: 48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

CO1 (L2 – Understand): Explain the principles of vaccinology, immune protection and antigen selection for vaccine development.

CO2 (L3 – Apply): Apply modern vaccine design strategies, expression systems and formulation approaches for developing candidate vaccines

CO3 (L4 – Analyze): Analyze upstream and downstream manufacturing processes for different vaccine platforms.

CO4 (L4 – Analyze): Analyze quality control, preclinical and clinical evaluation, and regulatory requirements for vaccine development.

CO5 (L5 – Evaluate): Evaluate emerging vaccine technologies and manufacturing strategies for infectious diseases and therapeutic applications.

Module-1

Principles of Vaccinology and Antigen Discovery

History and evolution of vaccines; principles of protective immunity; immune correlates of protection; antigen discovery and target identification; pathogen biology and virulence factors; epitope mapping; reverse vaccinology; structural vaccinology; immunoinformatics and AI-assisted antigen prediction; antigen prioritization for vaccine development.

Number of Hours: 08

Module-2

Vaccine Platforms and Manufacturing Technologies

Conventional vaccine platforms—live attenuated, inactivated, toxoid, subunit and conjugate vaccines; recombinant protein vaccines; viral vector vaccines; DNA, mRNA and self-amplifying RNA vaccines; peptide, nanoparticle and virus-like particle (VLP) vaccines; microbial, mammalian, insect and plant expression systems; adjuvants; delivery systems; formulation and stabilization strategies.

Number of Hours: 08

Module-3

Vaccine Process Development and Manufacturing

Cell banks and seed lot systems; upstream processing including inoculum preparation, cell culture, microbial fermentation and bioreactor operation; process optimization and scale-up; downstream processing including cell harvesting, clarification, purification, concentration, chromatography, ultrafiltration and sterile filtration; vaccine formulation, lyophilization, fill-finish operations, packaging, cold-chain management and process validation.

Number of Hours: 08

Module-4

Vaccine Quality, Safety and Regulatory Affairs

Quality by Design (QbD); analytical characterization of vaccines; potency, purity and sterility testing; adventitious agent testing; stability studies; Good Manufacturing Practices (GMP); Good Laboratory Practices (GLP); biosafety and biosecurity; preclinical evaluation; clinical trials (Phase I–IV); pharmacovigilance; WHO, CDSCO, USFDA and EMA regulatory guidelines; emergency use authorization and vaccine licensure.

Number of Hours: 09

Module-5

Advanced Vaccines and Industrial Applications

Vaccines against bacterial, viral and parasitic diseases; pandemic vaccine development; cancer vaccines; therapeutic vaccines; personalized vaccines; mucosal and needle-free vaccines; edible vaccines; combination vaccines; synthetic biology in vaccine development; AI and digital technologies in vaccine manufacturing;

continuous bioprocessing; next-generation vaccine production; case studies on COVID-19, HPV, pneumococcal and malaria vaccines.

Number of Hours: 09

Textbooks

1. Plotkin, S.A., Orenstein, W.A., Offit, P.A. and Edwards, K.M., Plotkin's Vaccines, 8th Edition, Elsevier.
2. Bloom, B.R. and Lambert, P.H. (Eds.), The Vaccine Book, 3rd Edition, Academic Press.
3. Bittle, J.L. and Murphy, F.A., Vaccine Biotechnology, Academic Press.

Reference Books

1. Kaufmann, S.H.E., Novel Vaccination Strategies, Wiley-VCH.
2. Janeway, C.A. et al., Janeway's Immunobiology, 10th Edition, Garland Science.
3. Kuby, J., Punt, J. and Stranford, S., Kuby Immunology, 9th Edition, W.H. Freeman

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Bioprocess Scale-up and Optimization			
Course Code	1MBT105C	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42:0:0: 48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

CO1 (L2 – Understand): Explain the principles, challenges, and strategies involved in scaling up bioprocesses from laboratory to pilot and industrial scale.

CO2 (L3 – Apply): Apply engineering principles and scale-up criteria to bioreactor operation, mixing, aeration, heat transfer, and mass transfer.

CO3 (L4 – Analyze): Analyze the effects of scale on microbial growth, oxygen transfer, mixing, shear, heat transfer, and process performance.

CO4 (L4 – Analyze): Analyze process parameters and apply statistical and computational approaches for bioprocess optimization.

CO5 (L5 – Evaluate): Evaluate scale-up strategies, process optimization approaches, process economics, quality considerations, and sustainability for industrial bioprocesses.

Module-1

Fundamentals of Bioprocess Scale-up

Introduction to bioprocess scale-up and scale-down; objectives and challenges of scale-up; laboratory, bench, pilot and industrial scales; similarity principles; geometric, kinematic and dynamic similarity; scale-up criteria and process variables; dimensional analysis; characteristic length and time scales; volumetric and specific quantities; scale-up based on constant power input, power per unit volume, tip speed, mixing time and oxygen transfer; scale-down concepts and model systems.

Number of Hours: 8

Module-2

Bioreactor Scale-up: Mixing, Mass Transfer and Heat Transfer

Scale-up of stirred-tank bioreactors; impeller selection and geometry; agitation and mixing; mixing time and circulation; power consumption and power number; Reynolds number; oxygen transfer and oxygen uptake; volumetric oxygen transfer coefficient (kLa); methods for kLa determination; oxygen transfer rate (OTR) and oxygen uptake rate (OUR); gas hold-up; aeration and sparger design; heat generation and heat removal; heat-transfer coefficients; temperature control; rheological effects and non-Newtonian systems.

Number of Hours: 8

Module-3

Scale-up of Microbial, Enzyme and Cell Culture Processes

Scale-up of microbial fermentation; growth kinetics and substrate utilization; product formation and yield; batch, fed-batch and continuous processes; scale-up of enzyme production and immobilized biocatalytic processes; scale-up of mammalian and plant cell cultures; shear sensitivity; cell damage and hydrodynamic stress; oxygen limitation; nutrient gradients; pH, temperature and dissolved oxygen control; process heterogeneity and scale-dependent effects.

Number of Hours: 8

Module-4

Bioprocess Optimization and Statistical Design

Principles of process optimization; identification of critical process parameters (CPPs) and critical quality attributes (CQAs); one-factor-at-a-time approach and its limitations; factorial design; fractional factorial design; response surface methodology (RSM); central composite and Box–Behnken designs; design of experiments (DoE); regression models and analysis of variance; optimization of medium composition and process conditions; multi-objective optimization; model validation and process robustness.

Number of Hours: 9

Module-5

Advanced Scale-up, Process Intensification and Industrial Applications
Scale-up and scale-down of continuous and intensified bioprocesses; perfusion and continuous biomanufacturing; single-use bioreactors; high-cell-density cultivation; process analytical technology (PAT); sensors and real-time process monitoring; digital twins and computational fluid dynamics (CFD) in bioprocess development; mechanistic and data-driven modelling; techno-economic analysis; process validation and GMP; Quality by Design (QbD); risk assessment; sustainability, energy efficiency and green bioprocessing; industrial case studies in biopharmaceutical and industrial biotechnology.

Number of Hours: 9

Textbooks
1. Doran, P. M., Bioprocess Engineering Principles, 2nd Edition, Academic Press.
2. Stanbury, P. F., Whitaker, A. and Hall, S. J., Principles of Fermentation Technology, 3rd Edition, Elsevier.
3. Shuler, M. L., Kargi, F. and DeLisa, M. P., Bioprocess Engineering: Basic Concepts, 3rd Edition, Pearson.

Reference Books
1. Nielsen, J., Villadsen, J. and Lidén, G., Bioreaction Engineering Principles, 3rd Edition, Springer.
2. Garcia-Ochoa, F. and Gomez, E., Bioreactor Scale-Up and Process Development, relevant advanced references.
3. Paul, E. L., Atiemo-Obeng, V. A. and Kresta, S. M., Handbook of Industrial Mixing: Science and Practice, Wiley.

Assessment Structure (both CIE and SEE)
The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.
Continuous Internal Evaluation:
Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]
A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.
In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Microbial Biotechnology			
Course Code	1MBT105D	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42: 0:0:48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

1. Understand Industrial Fermentations, Screening Methods and Strain Development.
2. Understand Different production Media, Principles of Sterilization and related equipment.
3. Analyse different fermenter designs and control their operation.
4. Analyse and evaluate different microbiological assays for biomolecules and pathogens.
5. Apply microbes for industrial uses.

Module-1

INTRODUCTION:

The era of the discovery of Microbes, Pasteur and fermentation, The discovery of Antibiotics, Production strains, screening techniques, Industrial Fermentations, Screening Methods, Strain Development.

Number of Hours:8

Module-2

PRODUCTION MEDIA:

Characteristics of an Ideal Production Media, Raw materials for production, Different production Media, Principles of Sterilization, Sterilization equipment.

Number of Hours:8

Module-3

PRINCIPAL TYPES OF FERMENTOR IN INDUSTRIES:

Introduction to Fermenters, Factors involved in fermenter Design, Fermenter configurations, Principal operating characteristics of fermenters, Computer control of Fermentation Process.

Number of Hours:8

Module-4

MICROBIOLOGICAL ASSAYS:

Microbiological assay of Vitamins, Amino Acids, Antibiotics and Trace elements. Advantages and Disadvantages of Microbiological Assay, Automation of Microbiological Assay, Detection methods for pathogens.

Number of Hours:8

Module-5

INDUSTRIAL APPLICATIONS OF MICROBES:

Food sector- Fermented foods, Production of food related metabolites like organic acids, vitamins by microbes; Enzyme Industries- Production of microbial enzymes used in food processing; Sewage treatment methods by using microbes.

Number of Hours:8

Textbooks:

1. Microbiology. Prescott, Joanne Willey and Kathleen Sandman and Dorothy Wood, Harley, Klein, McGraw Hill, 8th Edition, 2010.
2. Industrial Microbiology. Samuel C Prescott and Cecil G Dunn, Agro bios (India), 2011.
3. Palynology and its applications. Shripad N. Agashe, Oxfor and Ibh publishing Pvt. Ltd. 1st Edition, 2006.
4. Biotechnological Applications of Microbes. AjitVerma, I.K. International Publishing House, 1st Edition, 2005.

<u>Reference books / Manuals:</u>

1. Alcamo's Fundamentals of Microbiology. Jeffery C Pommerville, Jones and Bartlett Publisher, 9th Revised Edition, 2010.
2. Microbiology, an Introduction, Gerard J. Tortora, Berdell R. Funke, Christine L. Case, Publisher: Pearson, 12th Edition, 2016.
3. Principles of Microbiology. Ronald M Atlas, McGraw-Hill Inc., US, 1995.

4. Microbiology: Principles and Explorations, Jacquelyn G. Black and Laura J. Black, John Wiley & Sons, 8th Edition, 2012.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

ARTIFICIAL INTELLIGENCE IN BIOTECHNOLOGY AND HEALTHCARE			
Course Code	1MBT106A	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42: 0:0:48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

CO1 (L2 – Understand): Explain the principles of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) and their applications in genomics, biological sequence analysis, and precision medicine.

CO2 (L3 – Apply): Apply AI and ML techniques for protein structure prediction, structural biology, drug target identification, and computational protein engineering.

CO3 (L4 – Analyze): Analyze AI-driven approaches in drug discovery and development, including target identification, virtual screening, lead optimization, drug repurposing, and pharmacogenomics.

CO4 (L4 – Analyze): Analyze machine learning methods for multi-omics data integration, biomarker discovery, metabolomics, proteomics, pharmacogenomics, and precision therapeutics.

CO5 (L5 – Evaluate): Evaluate AI- and ML-based approaches for disease diagnosis, prognosis, clinical decision support, medical imaging, personalized healthcare, and ethical, legal, and regulatory aspects of AI in biotechnology and healthcare.

Module-1

Artificial Intelligence in Genomics

Overview of Artificial Intelligence (AI), AI fundamentals, Use-cases and applications of AI, Machine Learning (ML), Machine Learning workflow and terminologies and Deep Learning (DL); Brief history of AI and ML in Healthcare and Pharmacy, , computational models of intelligence; conceptual frameworks from cognitive and educational psychology, neuroscience. AI-driven genomic data processing and biological sequence analysis. AI-assisted genome assembly, sequence alignment, genome annotation, and error correction using biological databases. AI-based detection and interpretation of genetic variants, including SNPs, Indels, CNVs, and structural variants. Deep learning for variant calling, functional annotation, biomarker discovery, pharmacogenomics, disease-risk prediction, and personalized medicine. Case Study: Google DeepVariant for automated SNP and Indel detection and its applications in clinical genomics and precision healthcare.

Number of Hours:8

Module-2

MACHINE LEARNING IN PROTEIN STRUCTURE PREDICTION (8 HOURS):

Introduction to protein structure prediction, the protein folding problem, and the significance of protein structure in structural biology and drug discovery; limitations of X-ray crystallography, NMR spectroscopy, and Cryo-EM. Fundamentals of AI, Machine Learning, and Deep Learning for protein structure prediction. AlphaFold: architecture, workflow, Evoformer, pLDDT confidence score, and AlphaFold Protein Structure

Module-3

AI in Drug Discovery and Development (8 Hours)

Introduction to AI in the drug discovery pipeline and limitations of conventional drug discovery. AI and Machine Learning for target identification, validation, virtual screening, QSAR, molecular docking, binding affinity and molecular property prediction, and lead optimization. AI platforms including AtomNet, Schrödinger AI Suite, and generative AI approaches (GANs, Reinforcement Learning, and deep learning) for *de novo* drug design. Applications in drug repurposing, precision medicine, pharmacogenomics, biomarker discovery, clinical trial optimization, and vaccine development. Integration with molecular dynamics simulations, cheminformatics, and systems biology. Ethical, regulatory, and future perspectives of AI-driven drug discovery.

Number of Hours:8

Module-4

Machine Learning for Big Data, Metabolomics, Proteomics and Pharmacogenomics (8 Hours)

Machine Learning for Big Data, Metabolomics, Proteomics and Pharmacogenomics (8 Hours): Big data analytics in biochemistry and high-throughput omics datasets using Machine Learning for analysis of NGS, MS, NMR, microarray, metabolomics, proteomics, transcriptomics, and pharmacogenomic data. AI-assisted genomic variant analysis(SNPs), biomarker discovery, genotype–phenotype association, drug response prediction, and personalized medicine. Applications in multi-omics integration, systems biology, disease diagnosis, precision oncology, targeted therapies, pharmacogenomics-guided clinical decision support, AI-enabled drug discovery, and personalized drug therapy. Challenges, ethical, legal, and regulatory considerations, and future trends in AI-driven omics and precision therapeutics.

Number of Hours:8

Module-5

Machine Learning in Disease Diagnosis and Prognosis (8 Hours)

Machine Learning in Disease Diagnosis and Prognosis (8 Hours): Introduction to Artificial Intelligence (AI) and Machine Learning (ML) in disease diagnosis, prognosis, and clinical decision support. ML techniques for the analysis of Electronic Health Records (EHRs), medical imaging, genomic, and clinical data for disease detection and outcome prediction. Deep learning approaches, including Convolutional Neural Networks (CNNs), for medical image analysis, early disease diagnosis, and cancer detection. Applications of ML in predicting disease progression, risk stratification, biomarker discovery, chronic disease management, personalized treatment planning, and precision medicine. AI-assisted population health analytics for identifying at-risk populations and optimizing preventive healthcare strategies. Challenges, ethical, legal, and regulatory considerations, and future trends in AI-driven disease diagnosis and prognosis.

Number of Hours:8

Textbooks

1. Ekins, S., Artificial Intelligence in Drug Discovery, 1st Edition, Academic Press, 2020.
2. Bishop, C.M., Pattern Recognition and Machine Learning, Springer, 2006.
3. Goodfellow, I., Bengio, Y. and Courville, A., Deep Learning, MIT Press, 2016.
4. Baldi, P. and Brunak, S., Bioinformatics: The Machine Learning Approach, 2nd Edition, MIT Press.
5. Lesk, A.M., Introduction to Bioinformatics, 5th Edition, Oxford University Press.

Reference Books

1. Alpaydin, E., Introduction to Machine Learning, 4th Edition, MIT Press.
2. Murphy, K.P., Machine Learning: A Probabilistic Perspective, MIT Press.
3. Jurafsky, D. and Martin, J.H., Speech and Language Processing, 3rd Edition (Draft), Pearson. (Useful for NLP applications in biomedical text mining.)
4. Chakraborty, C., Bhattacharya, M. and Sharma, A.R. (Eds.), Artificial Intelligence in Healthcare, Academic Press.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

BIOSEPARATION TECHNIQUES			
Course Code	1MBT106B	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42: 0:0:48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

CO1 (L2 – Understand): Explain the principles and applications of major bioseparation techniques used for recovery and purification of biological products.

CO2 (L3 – Apply): Apply appropriate separation techniques for the isolation, concentration, purification, and recovery of biomolecules and bioproducts.

CO3 (L4 – Analyze): Analyze the influence of physicochemical properties of biomolecules on separation efficiency and product recovery.

CO4 (L4 – Analyze): Analyze and compare chromatographic, membrane-based, extraction, precipitation, and electrophoretic separation processes.

CO5 (L5 – Evaluate): Evaluate integrated downstream processing strategies based on purity, yield, productivity, scalability, economics, and product quality.

Module-1

Fundamentals of Bioseparation and Primary Recovery

Introduction to bioseparation and downstream processing; objectives and challenges of downstream processing; characteristics of biological products; product recovery, concentration and purification; physicochemical properties governing separation; selectivity, resolution, yield, recovery and purity; process economics; cell harvesting by centrifugation and filtration; sedimentation; flocculation; depth filtration; microfiltration; cell disruption methods – mechanical, physical, chemical and enzymatic methods; recovery of intracellular and extracellular products.

Number of Hours: 8

Module-2

Membrane-Based Bioseparation Processes

Principles of membrane separation; membrane materials and configurations; membrane transport mechanisms; concentration polarization and membrane fouling; microfiltration; ultrafiltration; nanofiltration; reverse osmosis; diafiltration; tangential flow filtration; membrane bioreactors; membrane selection and process design; membrane-based concentration and buffer exchange; scale-up considerations and applications in biopharmaceutical processing.

Number of Hours: 8

Module-3

Precipitation, Extraction and Adsorption

Principles of precipitation and phase separation; protein precipitation using salts, organic solvents and polymers; salting-out; isoelectric precipitation; aqueous two-phase extraction; liquid-liquid extraction; solid-liquid extraction; adsorption and desorption; activated carbon and ion-exchange adsorbents; partition coefficient and distribution behavior; affinity-based capture; factors affecting recovery and selectivity; applications in protein, enzyme and metabolite recovery.

Number of Hours: 8

Module-4

Chromatographic Separation and Purification

Fundamentals of chromatography; chromatographic modes and mechanisms; ion-exchange chromatography; size-exclusion chromatography; affinity chromatography; hydrophobic interaction chromatography; reversed-phase chromatography; chromatographic parameters – retention, selectivity, resolution, capacity and efficiency; column packing and operation; gradient and isocratic elution; process development and optimization; multi-step purification strategies; chromatography for proteins, enzymes, antibodies, nucleic acids and other bioproducts.

Number of Hours: 9

Module-5

Advanced Bioseparation and Integrated Downstream Processing

High-resolution purification and polishing; electrophoretic techniques – PAGE, SDS-PAGE and isoelectric focusing; ultracentrifugation and density-gradient separation; crystallization and drying; lyophilization; formulation and stabilization of biological products; integrated downstream processing flowsheets; process intensification; continuous downstream processing; single-use technologies; Quality by Design (QbD); Critical Quality Attributes (CQAs) and Critical Process Parameters (CPPs); process analytical technology (PAT); scale-up, validation, GMP, process economics and sustainability in bioseparation.

Number of Hours: 9

Textbooks

1. Belter, P. A., Cussler, E. L., Hu, W.-S., Schneiter, R. and Trevathan, K. A., Bioseparations: Downstream Processing for Biotechnology, Wiley.
2. Janson, J.-C., Protein Purification: Principles, High Resolution Methods, and Applications, 3rd Edition, Wiley-VCH.
3. Harrison, R. G., Todd, P. W., Rudge, S. R. and Petrides, D. P., Bioseparations Science and Engineering, 2nd Edition, Oxford University Press.

Reference Books

1. Scopes, R. K., Protein Purification: Principles and Practice, 3rd Edition, Springer.
2. Ladisch, M. R., Bioseparations Engineering: Principles, Practice, and Economics, Wiley.
3. Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, Wiley.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Functional Foods and Nutraceuticals			
Course Code	1MBT106C	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42: 0: 0: 48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

1. Understand various food ingredients and their functional properties.
2. Apply his understanding to select appropriate food for particular disease control.
3. Understand and evaluate functional foods with respect to different regulations.
4. Analyze the functional claims with respect to packaging and labelling.
5. Apply various regulations and laws imposed for functional food.

Module-1

INTRODUCTION:

Functional foods- concept and definition; nutraceutical-concept and definition. Probiotics, prebiotics and dietary fibres – their functional properties Functional foods-the link between nutrition and medicine, sources and bioavailability of nutraceuticals, chemistry and structure of nutraceuticals.

Number of Hours:8

Module-2

FUNCTIONAL FOOD COMPONENTS AND THEIR ROLES IN DISEASE PREVENTION:

Micronutrients, Vitamins, Isoflavones; Flavanoids, Carotenoids and Lycopene; Nutraceuticals – Garlic, Grape, Wine, Tea; Omega 3 Fatty Acids, Antioxidant, Chemoprevention & Functional Food; Single Cell Proteins. Functional foods for treatment of gastrointestinal disorders, Functional Food and Nutraceuticals for the treatment of Coronary Heart Disease, Role of Functional Food and Nutraceuticals in Tumor. Nutraceuticals and Functional Foods from Marine: Marine Macroalgae, Microalgae, Bacteria, Fungi, Cyanobacteria and their Therapeutic Applications. Marine-Derived Nutraceuticals for Prevention and Development of Atherosclerosis.

Number of Hours:8

Module-3

NUTRACEUTICALS OF PLANT AND ANIMAL ORIGIN:

Plant secondary metabolites: Role of Plant Sterols and Phytoestrogens in Functional Foods, Phenolics in Herbal and Nutraceutical Products. Animal metabolites: Fat rich functional food and their applications - Functional Fats and Spreads, modified fats and oils. Functional Meat as Functional Foods, Functional Confectionery and other functional Products.

Number of Hours:8

Module-4

FUNCTIONAL FOOD HEALTH CLAIMS:

Functional claims; packaging and labeling; nutrient modification and specific nutrient claims; disease-specific claims; Dietary Supplement Health and Education Act (DSHEA).

Number of Hours:8

Module-5

MARKETING AND REGULATION OF FUNCTIONAL FOODS:

Market for Functional Food Products: Functional foods and consumers; the role of health in food choice; functional foods market; Regulations and laws for functional food. Regulations in USA, EU and India.

Number of Hours:8

Textbooks:

1. Functional Foods: Principles and Technology. M. Guo, Woodhead Publishing, 1st Edition.
2. Functional foods-Concept to product. Gibson G.R., Williams G.M. Woodhead Publishing Ltd, 2000.
3. Handbook of Nutraceuticals and Functional Foods. Wildman R.E.C., Second Edition, CRC Press, 2007.
4. Handbook of fermented functional foods. Farnworth E.R., CRC Press, 2003.

<u>Reference books / Manuals:</u>

1. Phytochemical functional foods. Johnson I., Williamson G. Woodhead Publishing Ltd, 2000.
2. Phytosterol as functional food components and nutraceuticals. Dutta P.C., Marcel Dekker, 2004.
3. Functional food ingredients and nutraceuticals. Shi J., Taylor and Francis, 2007.

4. Biotechnology in functional foods and nutraceuticals. Bagchi D., Lau F.C., Ghsh, D.K., Taylor and Francis, 2010.
5. Dietary supplements and functional foods. Webb, G.P., Blackwell Publishing, 2006.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Enzyme and Fermentation Technology			
Course Code	1MBT106D	Scheme	2026
Type of Course	**PEC**	Semester	01
Teaching Hours/Week (L:T:P)	3: 0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW:	42: 0: 0: 48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

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

1. Understand enzyme kinetics.
2. Evaluate the enzymes for food processing applications.
3. Analyse and evaluate different methods for enzyme purification.
4. Create strategies for the production of enzymes by fermentation technology.
5. Analyse and evaluate different fermenter designs.

Module-1

INTRODUCTION AND ENZYME KINETICS:

Nature, Function, classification & nomenclature of enzymes, Specificity, Michaeli'sMenton equation, Km, Lineweaver Berk Plot, Different inhibitors.

Number of Hours: 8

Module-2

FOOD RELATED ENZYMES AND APPLICATIONS:

Amylases, Pectic Enzymes, Proteases, Rennet; Oxidoreductases- Phenolases, Glucose Oxidases, Catalases, Peroxidases, Lipoxygenases, Xanthine Oxidases, Immobilized enzyme, Application of enzymes in food processing; Application of immobilized enzymes and cells.

Number of Hours: 8

Module-3

ENZYME PURIFICATION:

Ammonium sulphate precipitation, Gel exclusion chromatography, Ion exchange chromatography, Affinity chromatography- GST, His tag, Native PAGE, SDS-PAGE, Zymogram, Coomassie blue and Silver staining.

Number of Hours: 8

Module-4

FERMENTATION TECHNOLOGY:

Sterilization methods of Fermentors; Scale up and scale down; Biomass Production; Enzyme Production; Downstream processing.

Number of Hours:8

Module-5

FERMENTORS:

Fermentor design and analysis; Aeration and Heat Transfer; Instrumentation and Control; Batch, Fed batch and continuous bioreactors.

Number of Hours:8

Textbooks:

1. Downstream Process Technology: A New Horizon In Biotechnology, Nooralabettu Krishna Prasad, PHI, 2012.
2. Enzyme technology: Pacemaker of Biotechnology, Nooralabettu Krishna Prasad, PHI, 2011.
3. Biochemical Engineering Fundamentals. J.E. Baily and D.F. Ollis, Mcgraw Hill Chemical Engineering Series, 1st Edition, 1986.

Reference books / Manuals:

1. Industrial Microbiology. Samuel C Prescott and Cecil G Dunn, Agro bios (India), 2011.
2. Principles of Fermentation Technology. P.F. Stanbury and A. Whitaker, Elsevier; 2nd Edition, 2008.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

Biomolecular Structure and Functional Analysis Laboratory			
Course Code	1 MBTL107A	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0: 0 :2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0: 28 :2	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

CO1: Apply biochemical techniques for the isolation and quantitative estimation of biomolecules from biological samples.
CO2: Demonstrate proficiency in the separation and characterization of biomolecules using chromatography, electrophoresis, precipitation, and dialysis techniques.
CO3: Analyze the structural, functional, and stability characteristics of proteins and other biomolecules using appropriate analytical methods.
CO4: Evaluate enzyme activity and kinetics by investigating the effects of pH, temperature, substrate concentration, and inhibitors.
CO5: Design and perform open-ended experiments, analyze experimental data, and interpret results to draw scientifically valid conclusions.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

1. Isolation and Quantitative Estimation of Proteins and carbohydrates from Biological Samples
2. Protein Fractionation by Ammonium Sulfate Precipitation and Dialysis
3. Separation and Molecular Weight Determination of Proteins by SDS-PAGE
4. Separation and Identification of Amino Acids by Paper Chromatography
5. Separation and Characterization of Biomolecules Using Thin Layer Chromatography
6. Protein Denaturation and Stability Analysis Under Different Physicochemical Conditions
7. Isolation and Characterization of Collagen/Gelatin from Biological Sources
8. Antioxidant Activity Analysis of Natural Extracts

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Concept 1 Effect of pH on enzyme-substrate interaction
2. Concept 2 Determination of enzyme kinetics and estimation of Km and Vmax

3. Concept 3 Study of reducing sugar content in different biological samples
4. Concept 4 Investigation of membrane permeability using biological membranes
5. Concept 5 Comparative study of nucleic acid content in biological samples
6. Concept 6 Investigation of protein–ligand binding using UV-Visible spectroscopy

Textbooks:

1. Nelson, D. L., & Cox, M. M., Lehninger Principles of Biochemistry, 8th Edition, W. H. Freeman/Macmillan Learning, 2021.
2. Berg, J. M., Tymoczko, J. L., Gatto, G. J., &Stryer, L., Biochemistry, 9th Edition, W. H. Freeman, 2019.
3. Wilson, K., & Walker, J., Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition, Cambridge University Press, 2018.

Reference Books / Manuals:

1. Plummer, D. T., An Introduction to Practical Biochemistry, 3rd Edition, McGraw-Hill Education.
2. Boyer, R. F., Modern Experimental Biochemistry, 3rd Edition, Pearson Education.
3. Sawhney, S. K., & Singh, R., Introductory Practical Biochemistry, Alpha Science International.

Web links and Video Lectures (e-Resources):

NPTEL – Experimental Biochemistry
MIT OpenCourseWare – Biological Chemistry I
MIT OpenCourseWare – Enzyme Kinetics
MIT OpenCourseWare – Enzymes and Catalysis
MIT OpenCourseWare – Enzyme Kinetics and Inhibition
NCBI Bookshelf – Molecular Biology of the Cell: Methods

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2

Table – 1 Distribution of marks corresponding to laboratory component		
Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component				
Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10				
Criteria and Guiding factors	**Students' Level and Rubrics**			
	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i)Logical structure and progression. (ii)Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5

(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i)Organization and neatness. (ii)Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5
Note: (i)The marks shown for *Excellent, Good, Fair, Needs Improvement* are indicative. The evaluator may also assign intermediate scores depending on the quality of work. (ii)If the total score results in a fraction, it should be rounded off to the next higher integer. (iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises. (iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.				

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Molecular Techniques in Food Biotechnology Laboratory

Course Code	**1MBTL107B**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0: 0 :2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0 : 28 :2	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

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

1. Apply molecular biology techniques for food quality, safety, and authentication.
2. Isolate and analyze nucleic acids from food and foodborne microorganisms.
3. Perform PCR-based techniques for identification and detection of foodborne pathogens and genetically modified organisms.
4. Analyze molecular data using bioinformatics tools for food biotechnology applications.
5. Design molecular approaches for solving problems in food quality assurance and food traceability.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   c. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   d. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

1. Isolation of genomic DNA from food samples (plant/animal origin) and foodborne microorganisms.
2. Qualitative and quantitative estimation of DNA using UV-Visible spectrophotometer and agarose gel electrophoresis.
3. Isolation of plasmid DNA from bacterial cultures.
4. Restriction enzyme digestion of DNA and analysis by agarose gel electrophoresis.
5. Polymerase Chain Reaction (PCR) amplification of microbial or food-specific genes.
6. Detection of genetically modified organisms (GMOs) in food samples using PCR (demonstration/data analysis where required).
7. Molecular identification of foodborne pathogens using PCR and sequence analysis.
8. Bioinformatics analysis of DNA sequences using NCBI, BLAST, and GenBank databases.

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Develop a PCR-based protocol for authentication of a selected food product.
2. Design a molecular workflow for rapid detection of foodborne pathogens in processed foods.
3. Perform comparative bioinformatics analysis of genes involved in food fermentation microorganisms.
4. Design molecular markers for identification of adulteration in food products.
5. Develop a molecular traceability strategy for a selected food supply chain.
6. Analyze publicly available genomic data to identify functional genes associated with probiotic microorganisms.

Textbooks:

1. Glick, B. R. and Pasternak, J. J., **Molecular Biotechnology: Principles and Applications of Recombinant DNA**, ASM Press.
2. Brown, T. A., **Gene Cloning and DNA Analysis: An Introduction**, Wiley-Blackwell.
3. Wilson, K. and Walker, J., **Principles and Techniques of Biochemistry and Molecular Biology**, Cambridge University Press.

Reference books / Manuals:

1. Primrose, S. B. and Twyman, R. M., **Principles of Gene Manipulation and Genomics**.
2. Watson, J. D. et al., **Molecular Biology of the Gene**, Pearson.
3. Nielsen, J. and Bensasson, D., **Molecular Biotechnology for Food Scientists**, Springer.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in
https://swayam.gov.in
https://www.ncbi.nlm.nih.gov
https://blast.ncbi.nlm.nih.gov
https://www.ebi.ac.uk
https://www.fssai.gov.in
https://www.fao.org

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2

Table – 1 Distribution of marks corresponding to laboratory component		
Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks

	Subtotal	**25**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10				
Criteria and Guiding factors	**Students' Level and Rubrics**			
	Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i)Logical structure and progression. (ii)Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25

(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i)Organization and neatness. (ii)Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i)The marks shown for *Excellent, Good, Fair, Needs Improvement* are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

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Food Product Development and Sensory Evaluation Laboratory			
Course Code	**1MBTL107C**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0: 0 :2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0 : 28 :2	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

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

1. Develop innovative food products using scientific principles of formulation and processing.
2. Evaluate the sensory, nutritional, physical, and functional properties of food products.
3. Apply statistical methods for sensory data analysis and product optimization.
4. Optimize food formulations to improve quality, shelf life, and consumer acceptability.
5. Design market-oriented value-added food products meeting regulatory and quality standards.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   e. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   f. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
List of experiments

1. Development and standardization of a functional food product using cereals, millets, pulses, fruits, or vegetables.
2. Formulation and quality evaluation of protein-enriched or fortified food products.
3. Preparation and optimization of low-calorie, low-fat, or sugar-free food products.
4. Development of probiotic or prebiotic food products and assessment of quality attributes.
5. Evaluation of physical properties of food products (colour, texture, viscosity, bulk density, water activity, etc.).
6. Sensory evaluation of food products using hedonic rating, ranking, paired comparison, triangle, and descriptive tests.
7. Shelf-life evaluation of developed food products under different storage conditions.
8. Statistical analysis of sensory data using ANOVA and other appropriate methods..

PART – B
OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Design and develop a novel ready-to-eat or ready-to-cook food product using locally available raw materials.
2. Develop a functional beverage enriched with natural bioactive ingredients and evaluate consumer acceptance.
3. Formulate a nutraceutical food product targeting a specific health condition (diabetes, obesity, anemia, etc.).
4. Develop a sustainable food product utilizing food processing by-products or agro-industrial waste.
5. Optimize formulation of a food product using Design of Experiments (DoE)/Response Surface Methodology (RSM).
6. Conduct a consumer preference study and prepare a commercialization plan for a newly developed food product.

Textbooks:

1. Earle, M. D. and Earle, R. L., **Creating New Foods: The Product Developer's Guide**, Woodhead Publishing.
2. Lawless, H. T. and Heymann, H., **Sensory Evaluation of Food: Principles and Practices**, Springer.
3. Fuller, G. W., **New Food Product Development: From Concept to Marketplace**, CRC Press.

Reference books / Manuals:

1. Stone, H. and Sidel, J. L., **Sensory Evaluation Practices**, Academic Press.
2. Moskowitz, H. R., Beckley, J. H., and Resurreccion, A. V. A., **Sensory and Consumer Research in Food Product Design and Development**, Wiley-Blackwell.
3. Meilgaard, M., Civille, G. V., and Carr, B. T., **Sensory Evaluation Techniques**, CRC Press..

Web links and Video Lectures (e-Resources):

https://nptel.ac.in
https://swayam.gov.in
https://www.ncbi.nlm.nih.gov
https://blast.ncbi.nlm.nih.gov
https://www.ebi.ac.uk
https://www.fssai.gov.in
https://www.fao.org

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.
A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."
Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)
Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.
The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.
The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test	5 marks

Performance	experiment.	
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10				
Criteria and Guiding factors	**Students' Level and Rubrics** **Excellent: E, Good: G, Fair: F** **Needs Improvements: NI**			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5
(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i)Logical structure and progression. (ii)Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i)Organization and neatness. (ii)Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i)The marks shown for *Excellent, Good, Fair, Needs Improvement* are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

Course Code	**1MBTL107D**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	1
Teaching Hours/Week (L:T:P)	0: 0 :2	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0: 0 : 28 :2	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1 (L2 – Understand): Explain the principles of microbial cultivation, fermentation processes, bioproduct development, and industrially important microbial metabolites.
2. CO2 (L3 – Apply): Apply fermentation strategies for the production of bio-based products such as antibiotics, biofuels, organic acids, pigments, and probiotic formulations.
3. CO3 (L4 – Analyze): Analyze fermentation parameters, product recovery methods, and analytical techniques for quality assessment of microbial products.
4. CO4 (L5 – Evaluate): Evaluate process optimization strategies, downstream processing approaches, and scale-up considerations for industrial bioproduct production.
5. CO5 (L5 – Evaluate): Evaluate emerging approaches in bioprocess development, including sustainable biomanufacturing, microbial engineering, and advanced fermentation technologies for commercial applications.

Note:

4. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
5. Both PART-A and PART-B are considered for CIE and SEE.
6. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   g. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   h. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A

List of experiments

1. Screening, Production and estimation of Penicillin
2. Wine/ethanol fermentation and quality analysis
3. Bioethanol production from renewable substrates
4. Organic acid fermentation process optimization
5. Microbial pigment production and recovery
6. Probiotic product development and stability testing
7. Downstream processing of fermentation products
8. Bioreactor scale-up and process parameter optimization

PART – B

OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Optimization of Microbial Production of Vitamins and Cofactors
2. Production of Single Cell Protein (SCP) from Microbial Biomass
3. Microbial Production of Antioxidant Compounds
4. Development of Microbial Platforms for Nanoparticle Biosynthesis
5. Microbial Production of Exopolysaccharides (EPS) and Functional Characterization
6. Optimization of Microbial Bioremediation Processes
7. Development of Synbiotic Product Formulations

Textbooks:

1. Stanbury, P. F., Whitaker, A. and Hall, S. J., Principles of Fermentation Technology, Butterworth-Heinemann.
2. Doran, P. M., Bioprocess Engineering Principles, Academic Press.
3. Shuler, M. L. and Kargi, F., Bioprocess Engineering: Basic Concepts, Prentice Hall.
4. Waites, M. J., Morgan, N. L., Rockey, J. S. and Higton, G., Industrial Microbiology: An Introduction, Blackwell Science.
5. Glazer, A. N. and Nikaido, H., Microbial Biotechnology: Fundamentals of Applied Microbiology, Cambridge University Press.
6. Demain, A. L. and Davies, J. E., Manual of Industrial Microbiology and Biotechnology, ASM Press.

Reference Books / Manuals:

1. Harrison, R. G., Todd, P., Rudge, S. R. and Petrides, D. P., Bioseparations Science and Engineering, Oxford University Press.
2. Moo-Young, M., Comprehensive Biotechnology, Elsevier.
3. El-Mansi, E. M. T., Bryce, C. F. A., Dahhou, B., Sanchez, S., Demain, A. L. and Allman, A. R., Fermentation Microbiology and Biotechnology, CRC Press.
4. Okafor, N., Modern Industrial Microbiology and Biotechnology, CRC Press.
5. Nielsen, J., Villadsen, J. and Lidén, G., Bioreaction Engineering Principles, Springer.
6. Kuila, A. and Sharma, V., Principles and Applications of Fermentation Technology, Wiley.

Web Links and Video Lectures (e-Resources):

https://nptel.ac.in/
https://ocw.mit.edu/
https://www.ncbi.nlm.nih.gov/
https://asm.org/
https://www.ebi.ac.uk/training/
https://www.coursera.org/
https://www.edx.org/
https://www.youtube.com/@nptelhrd
https://www.bioprocessintl.com/
https://www.sciencedirect.com/topics/

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)

Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.

The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.

The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2

Table – 1 Distribution of marks corresponding to laboratory component		
Component	**Description**	**Marks**
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component				
Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10				
Criteria and Guiding factors	**Students' Level and Rubrics** **Excellent: E, Good: G, Fair: F** **Needs Improvements: NI**			
	E	**G**	**F**	**NI**
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5

(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i)Logical structure and progression. (ii)Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i)Organization and neatness. (ii)Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i)The marks shown for *Excellent, Good, Fair, Needs Improvement* are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.