Semester- I

BIOSTATISTICS			
Course Code	MBT101	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Equip students with a solid foundation in biostatistics, including data classification, sampling methods, and descriptive statistics, essential for analyzing biological data.
- Enable students to apply various statistical techniques such as correlation, regression analysis, and distribution models to real-world biological problems.
- Provide students with the knowledge to design, conduct, and analyze biological experiments, ensuring the validity and reliability of experimental outcomes.
- Develop students' skills in inferential statistics, including hypothesis testing and error analysis, to draw meaningful conclusions from biological data.
- Introduce students to the application of biostatistics in genomics, particularly in the analysis of microarray data, and equip them with the tools to process and interpret complex genetic data.

Module-1

INTRODUCTION TO BIOSTATISTICS:

Introduction to Biostatistics, classification of variables, types of data, sorting of data, sampling methods, representation of data-tabular, diagrammatic (bar diagram, line diagram, pie chart), graphical (Histogram, frequency polygon, frequency curve), box plot and pictorial, Measure of dispersion- standard deviation, quartile deviation, mean deviation, variance and coefficient of variation, logarithmic mean and harmonic mean, kurtosis and skewness. Application of descriptive statistics, case studies.

Module-2

BI-VARIATE ANALYSIS

Statistical Correlation, types of correlation, methods of correlation, Karl Pearson correlation coefficient, Spearman Rank correlation Coefficient, regression analysis- linear and non-linear, curve fitting, linearization and its application in biological studies, Baye's theorem, binomial distribution, poisson distribution, normal distribution, Significance of statistics to biological problems, case studies.

Module-3

STUDY DESIGN AND ANALYSIS OF EXPERIMENTS:

Basics of study design, selectivity, specificity and sensitivity with problems, biases, limitations, multiple sources of variation, replication, randomisation and blocking, experimental studies- Randomized controlled studies, historically controlled studies, cross over, cohort studies, case-control studies, outcomes, odd ratio and relative risks, factorial design- main effect and interaction effect, cluster design, stratified design, randomization, single blind and double blind experiments, Randomized controlled studies- Random block design, Completely randomized design, Ethical considerations, case studies

Module-4

INFERENTIAL STATISTICS:

Point estimation, interval estimation- single mean and two mean, sample size estimation, testing of hypothesis, Test statistics-z-test, t-test, F-test, chi-squared test, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA- One-way and Two-way, T-tests; application of inferential statistics in epidemiology, type 1 error and type II error, Case studies.

Module-5

STATISTICS IN MICROARRAY:

Microarray tool for gene expression analysis, Types of microarrays, fabrication of microarray, digital image processing of microarrays, microarray analysis and visualisation tools-box plots, gene pies, scatter plot, data pre-processing techniques, ANOVA for data analysis

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Books

1. Biostatistics, Alvin E. Lewis, McGraw-Hill Professional Publishing, 2013
2. Statistics and Numerical Methods in BASIC for Biologists, D. Lee and T.D. Lee, Van Nostrand Reinhold Company, 1982
3. Numerical Methods, Wolfgang Boehm and Hartmut Prautzsch, CRC Press, 1993
4. Numerical Methods of Statistics, John F. Monahan,Cambridge University Press, 2011 Numerical Methods for Engineers and Joe D. Hoffman CRC Press 2001
5. Statistical Methods in Bioinformatics: An Introduction Warren, J. Ewensregory Grant, Springer Science & Business Media, 2005.

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/102/106/102106051/
2. https://archive.nptel.ac.in/courses/111/102/111102112/
   https://archive.nptel.ac.in/courses/103/106/103106120/
3. https://www.youtube.com/watch?v=KhjM8YI3agk
4. https://nptel.ac.in/courses/102106065.

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Students will be able to identify and classify different types of variables and data, and recall the methods of data representation and measures of dispersion.	L1
CO2	Students will understand the concepts of correlation, regression, and various distribution models, and explain their significance in biological data analysis.	L2
CO3	Students will apply knowledge of study design principles and statistical methods to conduct and analyze biological experiments effectively.	L3
CO4	Students will analyze data using inferential statistical techniques, including hypothesis testing and error analysis, to interpret biological data accurately.	L4
CO5	Students will evaluate microarray data through advanced statistical methods, assessing the significance and reliability of gene expression analyses.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO12

Mapping of COS and POs

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

Semester -I

BIOPROCESS TECHNOLOGY			
Course Code	**MBT102**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	4	Exam Hours	3

Course objectives:

- Develop an understanding of media design principles and optimization techniques, focusing on industrial and commercial applications using statistical tools like Plackett Burman design and Response Surface Methodology.
- Gain knowledge of sterilization methods for fermentation processes, including the kinetics of thermal death, design of thermal sterilization processes, and alternative sterilization techniques such as radiation and chemical methods.
- Explore the kinetics of microbial growth and product formation using unstructured models, understanding the relationship between cell growth, product formation, and associated kinetic models.
- Learn the principles of mass transfer, including molecular diffusion, Fick's law, and the application of these principles in the design and operation of stirred tank reactors.
- Understand the principles of reactor design for homogeneous systems, including batch, continuous, and fed-batch reactors, and develop skills.

Module-1

MEDIA DESIGN AND OPTIMISATION USING STATISTICAL TOOLS

Design of media for commercial and industrial applications. Plackett Burman design, Response surface methodology – Central composite design.

Module-2

STERILIZATION FOR FERMENTATION PROCESSES

Kinetics of thermal death of cells & spores, Design of batch and Continuous thermal sterilization, Coupling of Arrhenius equation and cell death kinetics, Sterilization of air and filter design, Radiation and chemical sterilization.

Module-3

KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION (UNSTRUCTURED MODEL)

Kinetics of cell growth and product formation; Simple unstructured kinetic models for microbial growth; Growth associated and non-growth associated product formation kinetics; Monod and Leudeking-Piret models.

Module-4

MASS TRANSFER

Principles of molecular diffusion, Fick's law of diffusion, diffusion of gases and liquids, theories of mass transfer, concept of mass transfer coefficients. Mass transfer and power requirement in stirred tank reactors.

Module-5

REACTORS, SCALE – UP OF REACTORS

Design for homogeneous systems, Batch, Continuous and Fed-batch systems. Reactors in series - Non-Ideality in reactors. Scale up criteria -procedure and scale-down.

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Classical method of media optimization .
2	Statistical method of media optimization(Plackett Burman).
3	Statistical method of media optimization (Response Surface Methodology).
4	Thermal death kinetics of microorganisms.
5	Growth kinetics in Batch culture .
6	Product kinetics in Batch culture.
7	Estimation of mass transfer coefficient using dynamic degassing methods.

8	Flow reactors – Air-lift,
9	Flow reactors –Packed –bed
10	Flow reactors –Fluidized bed reactors
11	Citric acid production using Table top fermenter
12	Vine production using grapes

Assessment Details (both CIE and SEE)

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

CIE for the theory component of IPCC

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

CIE for the practical component of IPCC

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

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

SEE for IPCC

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

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

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

the practical component).

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

Suggested Learning Resources:

Books

1. Michael L. Shuler, Fikret Kargi, Matthew DeLisa 2017. Bioprocess Engineering, 3rd Edition, Prentice Hall International Series.
2. Peter Stanbury, Principles of Fermentation technology 2015, third edition, Butterworth- Heinemann
3. Shigeo Katoh and Fumitake Yoshida, 2010, Biochemical Engineering - A Textbook for Engineers, Chemists and Biologists, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=DF4ba5AHDiY
2. https://www.youtube.com/watch?v=rJYEmRhgPxo
3. https://www.youtube.com/watch?v=f95B06bRfec
4. http://digimat.in/nptel/courses/video/102105064/L01.html
5. http://acl.digimat.in/nptel/courses/video/102105058/L20.html

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

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Recall the fundamental principles of media design and optimization techniques used in industrial applications.	BTL 1
CO2	Explain the kinetics of thermal death of cells and spores, and describe the design principles for thermal sterilization processes in fermentation.	BTL 2
CO3	Apply unstructured kinetic models to analyze microbial growth and product formation in different fermentation processes..	BTL 3
CO4	Analyze the principles of mass transfer and determine the mass transfer coefficients in stirred tank reactors.	BTL 4
CO5	Evaluate the design and scale-up criteria for reactors, considering factors like non-ideality and scale-down procedure	BTL 5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

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

Semester- I

ADVANCED BIOCHEMISTRY			
Course Code	MBT103	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Develop a foundational understanding of biochemistry, including the principles of solutions, pH, buffers, and the characteristics of biomolecules relevant to bioprocesses.
- Gain in-depth knowledge of carbohydrate structures, metabolism, and their regulatory mechanisms, including the role of redox reactions and energy metabolism.
- Study the structural organization of proteins, their structure-activity relationships, and the mechanisms of enzyme action.
- Understand the structure, properties, and functions of membrane lipids and proteins, as well as the processes of lipid metabolism and membrane transport.
- Learn about the types of cellular signaling, receptor types, and the mechanisms of transport and signal transduction within cells.

Module-1

INTRODUCTIONNTO BASIC BIOCHEMISTRY CONCEPTS.

Basic concepts of solutions Effect of solvent and additive Mechanism of solvation Normality, Molartity, Molality Percentage Ph and Buffers for biochemical reagents, buffering capacity, and numerical problems on buffer preparation, pH and the Henderson- Hasselbalch equation. Characteristics of Biomolecules relevant to Bioprocesses Carbohydrate, Proteins and Lipids.

Module-2

CARBOHYDRATES

stereoisomerism, sugar derivatives, disaccharides, homo and heteropolysaccharides, glycosaminoglycan (GAGs), proteoglycans, bacterial cell wall polysaccharides, glycoproteins, lectins and medical applications of oligosaccharides. Basic Carbohydrate metabolism and regulation. Redox reactions, redox potential and Nernst equation. Thermodynamics. High energy compounds. Role of ATP in energy metabolism. Substrate level phosphorylation, Oxidative phosphorylation and photophosphorylation

Module-3

PROTEINS

Structural organisation of Proteins. Structure activity relationship of proteins- haemoglobin, myoglobin, collagen, keratin, Insulin, Enzyme coenzymes and cofactors. Mechanism of enzyme action, with reference to serine proteases.

Module-4

LIPIDS AND MEMBRANES

Membrane lipids & proteins; structure & properties of membrane lipids; fluid mosaic model; function (carriers, receptors, enzymes, anchors, cell-cell recognition); osmosis & diffusion, tonicity; TAG catabolism, anabolism (animal metabolism)

Module-5

Signalling and Transport

Signaling types, receptor types (intra vs surface); transport: bulk (endocytosis, exocytosis), selective (facilitated, active); ion channels, transporters; signal transduction cascades: GPCRs, cytokine, TK; apoptosis.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Books

1. David L Nelson, Michael M Cox, Albert L Lehninger (2013) Lehninger Principles of Biochemistry - 6th edition, New York : W.H. Freeman.
2. Jeremy M Berg, John L Tymoczko, Gregory J Gatto, Lubert Stryer (2015) Biochemistry - 8th Edition, Palgrave MacMillan.
3. Donald Voet, Judith G Voet (2010) Biochemistry - 4th Edition, Wiley India Pvt Ltd.

Web links and Video Lectures (e-Resources):

1. https://www.digimat.in/nptel/courses/video/102106087/L01.html
2. https://www.youtube.com/watch?v=82yp3h2IzlQ
3. https://www.digimat.in/nptel/courses/video/102105034/L21.html
4. http://acl.digimat.in/nptel/courses/video/102106087/L12.html
5. https://www.digimat.in/nptel/courses/video/104105102/L29.html

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Recall the basic concepts of solutions, pH, buffers, and the characteristics of carbohydrates, proteins, and lipids.	L1
CO2	Explain the stereoisomerism of carbohydrates, sugar derivatives, and the basic mechanisms of carbohydrate metabolism and energy regulation.	L2
CO3	Apply knowledge of protein structure to analyze structure-activity relationships and enzyme mechanisms in biochemical processes.	L3
CO4	Analyze the structure and function of membrane lipids and proteins, and evaluate their roles in osmosis, diffusion, and cell signaling.	L4
CO5	Evaluate the mechanisms of cellular signaling and transport, including signal transduction cascades and their implications in cellular function and apoptosis.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO12

Mapping of COS and POs

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

Semester- I

APPLIED MICROBIOLOGY			
Course Code	MBT104	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Understand the principles and methods of microbial classification and the structure of various microorganisms.
- Analyze the factors influencing microbial growth and the methods used to control microbial populations.
- Comprehend the various microbial interactions and their roles in ecosystems and human health.
- Apply knowledge of industrial microbiology to bioprocesses and environmental applications.
- Evaluate microbial processes, including production, optimization, and enzyme technology, for industrial applications.

Module-1

MICROBIAL CLASSIFICATION AND STRUCTURE

Classical and modern methods and concepts; Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Molecular methods – Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (TRFLP) in assessing microbial diversity; 16S rDNA sequencing. Ultrastructure of Archaea (Methanococcus); Eubacteria (E.coli); Unicellular Eukaryotes (Yeast) and viruses(Bacterial, Plant, Animal and Tumor viruses).

Module-2

MICROBIAL GROWTH AND CONTROL

Culture media. Isolation and identification of microbes, culture techniques. Preservation of cultures Microbial growth: Growth kinetics, Thermal death kinetics, Batch, fed-batch, continuous culture, synchronous growth, yield constants methods of growth estimation, stringent response, death of a bacterial cell.; Physical and chemical methods for the control of microbes. Sterilization.

Module-3

MICROBIAL INTERACTION

Microbial interaction -Symbiosis (Nitrogen fixation and ruminant symbiosis); Antagonism (Pathogenesis) Microbes and Nutrient cycles; Microbial communication system- Quorum sensing, Biofilms; Microbial fuel cells; Prebiotics and Probiotics; Vaccines, Multidrug resistance-Mechanism and Example. Extremophiles (with classical example from each group).

Module-4

INDUSTRIAL APPLICATIONS

Basic principles in bioprocess technology; Media Formulation; Sterilization- Batch and continuous sterilization systems; Primary and secondary metabolites; Biotechnologically important products; Extracellular enzymes exopolymers; Bioprocess control and monitoring variables such as temperature, agitation, pressure, pH. Environmental application of microbes; Ore leaching; Toxic waste removal; soil remediation.

Module-5

MICROBIAL PROCESSES

Microbial processes-production, optimization, screening, strain improvement; factors affecting downstream processing and recovery; Representative examples of ethanol, organic acids, Antibiotics; Enzyme Technology production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillinacylase, glucose isomerase; Immobilised Enzyme and Cell -application, biotransformations-steroids, antibiotics, alkaloids

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks**

to attain the COs and POs

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Books

1. Prescott's Microbiology, 8th Edition, Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton. McGraw Hill Higher Education, 2008
2. Pelczar M.J.Jr., Chan E.C.S. and Kreig N R., Microbiology, 6th Edition, Tata McGraw Hill, 1993.
3. Maloy S.R., Cronan JE Jr. and Freifelder D, Microbial Genetics, Jones Bartlett Publishers 2nd Edition, Jones & Bartlell Publisher, 1994.
4. Crueger and A.Crueger, A Textbook of Industrial Microbiology, Sinauer Associates Inc, 2nd Edition, 2001

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=Bhe6Tj2Ebys
2. https://www.youtube.com/watch?v=cdeScYRotrU
3. https://www.youtube.com/watch?v=shWayTlt4hk
4. https://www.youtube.com/watch?v=9USGWb8Af2Y

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Recall the classical and modern methods of microbial classification, including the criteria and molecular techniques used for assessing microbial diversity.	L1
CO2	Explain the principles of microbial growth kinetics, culture techniques, and the various methods for controlling microbial growth.	L2
CO3	Apply knowledge of microbial interactions to analyze their roles in nutrient cycles, symbiosis, and biotechnological processes.	L3
CO4	Analyze the principles of bioprocess technology and evaluate the role of microbes in industrial applications such as ore leaching, toxic waste removal, and soil remediation.	L4
CO5	Evaluate microbial processes involved in the production and optimization of industrial products, and assess factors affecting downstream processing and recovery in biotechnological applications.	L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO12

Mapping of COS and POs

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

Semester- I

BIOANALYTICAL TECHNIQUES			
Course Code	MBT105	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Grasp the basic principles underlying various spectroscopic and chromatographic techniques, including their interaction with electromagnetic radiation.
- Acquire knowledge of the instrumentation and technical details involved in techniques such as NMR, ESR, mass spectrometry, X-ray spectroscopy, and chromatography.
- Develop the ability to interpret and analyze spectra, diffraction patterns, and chromatograms to derive meaningful conclusions about molecular structure and composition.
- Understand how these analytical techniques can be applied to solve complex problems in biology, pharmacy, and related fields.

Module-1

ELECTROMAGNETIC SPECTRUM AND ABSORPTION OF RADIATIONS:
Electro-magnetic Spectrum, Theory of spectroscopy, Scattering, Emission and absorption by molecules, choice of solvent and solvent effects, modern instrumentation – design and working principle. Principles of vibrational spectroscopy, instrumentation, interpretation of sample spectra, applications in biology. FTIR - theory, instrumentation and applications in biology, interpretation of sample spectra Attenuated Total Reflectance (ATR) – theory and applications in biology, interpretation of sample spectra. Laser Raman Spectroscopy - theory, instrumentation, and applications to biology, interpretation of sample spectra. UV-Visible spectroscopy - Theory, Beer-Lambert's law, instrumentation and Applications in biology, interpretation of sample spectra. Fluorescence Spectroscopy.

Module-2

NMR, ESR / EPR and CD / ORD SPECTROSCOPY:
NMR: Theory and Instrumentation, solvents, chemical shift, and factors affecting chemical shift, spin-spin coupling, coupling constant, and factors influencing the value of coupling constant, spin-spin decoupling, proton exchange reactions, FT-NMR, 2D –NMR, Difference between Proton NMR and C13 NMR. Applications in biology and Pharmacy, interpretation of sample spectra. Magnetic resonance Imaging (MRI).
ESR:
Theory and Instrumentation, interpretation of sample spectra, Hyperfine interactions and spectral splitting, Spin labelling techniques and their applications. Interpretation of sample spectra.
Circular Dichroism: basics of polarization, the origin of optical activity, Circular birefringence and optical rotation, Theory and Instrumentation, Circular dichroism and the study of biological molecules. Interpretation of sample spectra. ORD Principle, Plain curves, curves with cotton effect, octant rule and its applications, circular dichroism and its relation to ORD.

Module-3

MASS SPECTROSCOPY:
Fragmentation processes and fragmentation pattern, Chemical ionization mass spectroscopy (CIMS), Field Ionization Mass Spectrometry (FIMS), Fast Atom Bombardment MS (FAB MS), Matrix Assisted laser desorption / ionization MS (MALDI-MS), Tandem MS techniques: GC-MS. LC-MS. MS-MS. Discussions with Case studies.

Module-4

X-RAY SPECTROSCOPY:
Generation of X-rays, X-ray diffraction, Bragg's law, X-ray powder diffraction, interpretation of diffraction patterns and applications. Single crystal diffractions of biomolecules. Fibre diffraction. Neutron diffraction. The basic physical process in XAS, characteristic excitation energies of various elements, X-ray absorption in condensed matter, XAS and valence state, XAS and local atomic structure, applications of X-ray Photoelectron Spectroscopy (XPS), photoelectric effect, binding energies, instrumentation, qualitative analysis. X-ray fluorescence spectroscopy and applications. Energy Dispersive X-ray Spectroscopy (EDS/EDX) and applications.

Module-5

CHROMATOGRAPHIC TECHNIQUES:
Classification of chromatographic methods based on mechanism of separation: paper chromatography, thin layer chromatography, column chromatography - ion exchange chromatography, affinity chromatography. Gel filtration chromatography – technical questions and applications. Single step purification by Ni-NTA column. Gas Chromatography: Theory and principle, column operation, instrumentation, derivatisation methods and applications. HPLC, HPTLC, GC-MS, LC-MS. Discussions with Case studies.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

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

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

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

Semester-End Examination:

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

Suggested Learning Resources:

Books

1. Fundamentals of Bioanalytical Techniques and Instrumentation, Sabari Goshal & A K Srivastava, PHI, 2009
2. Principles of Instrumental Analysis, 4th Edition, Donglas A. Skoog, James, J. Leary, Saunders College Publishing, Philadelphia,1992
3. Practical Pharmaceutical Chemistry, 4thEdition, H. Beckett & J. Stenlake, Academic Press, 1988
4. Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House Meerut, 2000
5. Biochemical Methods of Analysis, Saroj Dua & Neera Garg, Alpha Science, 2010

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/104/106/104106122/
2. https://archive.nptel.ac.in/courses/104/108/104108097/
3. https://archive.nptel.ac.in/courses/115/105/115105122/
4. https://onlinecourses.nptel.ac.in/noc21_bt50/preview
5. https://archive.nptel.ac.in/courses/102/107/102107028/

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Recall fundamental principles of spectroscopy, including electromagnetic spectrum, scattering, emission, absorption, and the theoretical aspects of various spectroscopic techniques	L1
CO2	Explain the principles of different spectroscopic and chromatographic techniques, such as UV-Visible spectroscopy, FTIR, NMR, and their applications in biological contexts.	L2
CO3	Apply knowledge of spectroscopic and chromatographic techniques to interpret sample spectra, perform experimental analysis, and solve practical problems in biology and chemistry..	L3
CO4	Analyze complex spectra and chromatographic data to identify compounds, determine their concentrations, and understand their structural and chemical properties.	L4
CO5	Evaluate the effectiveness and limitations of different analytical techniques in solving specific research problems, and propose improvements or alternative methods based on the results obtained.	L4

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO3
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	PO4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO12

Mapping of COS and POs

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

ADVANCED BIOCHEMISTRY LAB			
Course Code	**MBTL106**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:2:2	SEE Marks	50
Credits	2	Exam Hours	3

Course objectives:

- Gain proficiency in a variety of analytical methods for determining the chemical composition of food and biological samples, including moisture content, ash, protein, fat, and carbohydrates.
- Acquire hands-on experience with laboratory equipment and techniques, including the hot air oven, muffle furnace, Kjeldahl apparatus, Soxhlet extractor, and colorimetric methods.
- Learn to perform accurate quantitative analysis of food and biological samples, using titrimetric and colorimetric methods for assessing acidity, sugar content, and other constituents.
- Develop the ability to prepare samples and utilize basic instrumentation practices for chemical analysis, ensuring precise and reliable results.
- Enhance skills in evaluating and interpreting analytical data, including the assessment of sensory properties using techniques like the 9-Point Hedonic Scale.

Sl.NO	Experiments
1	Determination of Moisture Content by Hot Air Oven Method
2	Determination of Crude Ash content Using Muffle Furnace
3	Determination of Crude Protein by Kjeldahl/Biuret /Lowry's /Bradford Method
4	Determination of Crude Fat by Soxhlet Method
5	Determination of Total Carbohydrate by Furfural Colorimetric /Anthrone Reagent/Phenol Sulphuric Acid methods
6	Estimation of Titrable Acidity by Titrimetric method/ pH Meter.
7	Estimation of Reducing Sugar by Titration/Nelson-Somogyi's /Dinitro Salicylic Method
8	Estimation of Total Sugar and Non-Reducing Sugar
	Demonstration Experiments (For CIE) if any
9	Comparing Sensory evaluation of the subjective parameters on 9 Point Hedonic Scale to objective parameters of food items.
10	Basic Instrumentation Practices
11	Sample Preparation for Chemical Analysis
12	Determination of Constituents by Physical Methods

Course outcomes (Course Skill Set):

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

1. Recall the procedures for determining moisture content, crude ash, and crude protein using standard laboratory methods.
2. Explain the principles behind the methods used for crude fat determination, carbohydrate analysis, and acidity estimation.

3. Apply the Soxhlet method to determine crude fat content and the Nelson-Somogyi's method to estimate reducing sugars in various samples.
4. Analyze the results of titrimetric and colorimetric assays to differentiate between total sugar and non-reducing sugar content in samples.
5. Evaluate the accuracy and reliability of experimental data by comparing different analytical techniques and interpreting the results from basic instrumentation practices.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation (CIE):

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

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

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

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

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

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

All laboratory experiments are to be included for practical examination.

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

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

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

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

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

The duration of SEE is 03 hours

Suggested Learning Resources:

1. S. Suzanne Nielsen, Food Analysis, Springer, 2017 (4th Edition)
2. P. A. E. Chichester and M. L. V. Martin, Methods of Food Analysis: Physical, Chemical, and Instrumental, Academic Press, 1991
3. American Public Health Association (APHA), Standard Methods for the Examination of Dairy Products, American Public Health Association, Year of Publication: 2011 (17th Edition)
4. Leo M. L. Nollet and Fidel Toldrá, Handbook of Food Analytical Chemistry: Chemical, Sensory, and Instrumental Methods, Wiley, 2004
5. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 2017 (7th Edition)

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