MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL
(Formerly West Bengal University of Technology)
Syllabus of B. Sc in Biotechnology
(Effective from 2023-24 Academic Sessions)

SEVENTH SEMESTER

Course Name: Genomics, Proteomics and Bioinformatics **Code: BMBT 7401**
Credits: 3 **Modes: Offline**
Total hours: 45 hrs

Aim of the course: This course aims to introduce students to the fundamental concepts of genomics, proteomics, and bioinformatics. It provides a basic understanding of genome organization, DNA sequencing, protein structure, and the use of computational tools and databases in biological research.

Course objectives: The objectives of this course are to introduce students to the basic principles of DNA sequencing, genome organization, and major biological databases. Students will gain a foundational understanding of protein structure, basic proteomics techniques, and the role of bioinformatics in organizing and analyzing biological data. By the end of the course, students should be able to use key databases, understand sequence alignment concepts, and appreciate how genomic and proteomic data contribute to our understanding of living systems.

Sl	Graduate Attributes	Mapped Modules
CO1	Describe the flow of biological information and explain the basic principles of DNA sequencing methods including Maxam-Gilbert and Sanger sequencing, and outline the concept of genome sequencing.	M1
CO2	Identify and use key web-based genomic databases such as NCBI, GenBank, and EMBL for accessing and interpreting biological sequence data.	M2
CO3	Define single nucleotide polymorphisms (SNPs), distinguish between their types, and recognize their basic relevance to genetic variation and disease.	M3
CO4	Describe the levels of protein structure and explain the basic chemical and physical properties of proteins and common methods for estimating protein size.	M4
CO5	Outline the goals of proteomics and explain the basic principle of 2D-PAGE and mass spectrometry as tools for protein identification.	M5
CO6	Identify major protein databases, describe the Protein Data Bank, and understand the basic concepts of transcriptomics and metabolomics.	M6
CO7	Describe the history, scope, and importance of bioinformatics and explain how it relates to the central dogma of molecular biology.	M7
CO8	Use basic sequence file formats, explain data submission and retrieval tools, and understand simple sequence alignment methods.	M8, M9

Learning Outcome/Skills: To impart basic knowledge about the following

- Understand the basic flow of genetic information and the principles behind common DNA sequencing techniques.
- Access and navigate major genomic databases including NCBI, GenBank, and EMBL.
- Define and classify SNPs and appreciate their role in genetic variation and human disease.
- Describe the structural organization of proteins and basic techniques used to study them.

- Understand the concept of proteomics and the use of 2D-PAGE for protein separation.
- Identify key protein databases and understand their role in storing and retrieving protein information.
- Appreciate the scope and history of bioinformatics and its importance in modern biology.
- Use basic bioinformatics tools for sequence submission, file formats, and data retrieval.
- Understand the concept of sequence alignment and the basic idea behind similarity searching.
- Develop a foundational ability to read and discuss biological data from genomic and proteomic sources.

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
THEORY						
M1	**Introduction to Genomics**	Information flow in biology; DNA sequencing methods (Maxam-Gilbert, Sanger); Introduction to genome sequencing (Shotgun); Basic idea of sequence assembly	6	15%	2, 3	Foundation of genomics
M2	**Genomic Databases**	Introduction to web-based genomic resources: NCBI, GenBank, EMBL; Basic concept of INSDC	5	10%	2, 3	Genomic data resources
M3	**Single Nucleotide Polymorphisms**	Concept of genome variation; Definition and types of SNPs (Missense, Synonymous, Frameshift); Basic idea of DNA microarray	4	8%	2, 3	Introductory level
M4	**Structure and Properties of Proteins**	Levels of protein structure; Basic chemical properties; Size determination methods: Native PAGE, SDS-PAGE	5	12%	2, 3	Protein biochemistry basics
M5	**Introduction to Proteomics**	Goals of proteomics; Basic principle of 2D-PAGE; Introduction to mass spectrometry for protein identification	5	12%	2, 3,4	Core proteomics concepts
M6	**Protein**	Protein Data Bank	5	10%	3, 4	Database

	Databases	(PDB); Overview of protein sequence databases; Basic concept of transcriptomics and metabolomics				literacy
M7	**Introduction to Bioinformatics**	History and importance of bioinformatics; Goals and scope; Central dogma and bioinformatics	5	10%	1, 2	Conceptual foundation
M8	**Data Generation and Retrieval**	Sequence file formats (FASTA, GenBank, EMBL); Data retrieval using NCBI Entrez; Introduction to sequence submission	4	8%	3, 4, 5	Practical skills
M9	**Sequence Alignment**	Concept of sequence similarity; Basic alignment methods (Dot matrix, BLAST); Local and global alignment; Concept of identity and homology	6	15%	3, 5	Core alignment concepts
Total Theory			**45**	**100**		

Detailed Syllabus

Module 1: Introduction to Genomics: Information flow in biology (DNA → RNA → Protein). Introduction to DNA sequencing: Maxam-Gilbert chemical cleavage method and Sanger's dideoxy chain termination method. Basic concept of genome sequencing: Shotgun sequencing approach. Introduction to genome sequence assembly. **(Total Hours: 6)**

Module 2: Genomic Databases: Introduction to major web-based genomic databases: NCBI Genome, GenBank, and EMBL. Basic concept of INSDC (International Nucleotide Sequence Database Collaboration). Overview of selected model organism genomes and their associated databases. **(Total Hours: 5)**

Module 3: Single Nucleotide Polymorphisms: Concept of genome variation. Definition of Single Nucleotide Polymorphisms (SNPs). Types of SNPs: Missense, Synonymous, and Frameshift. Basic relevance of SNPs to genetic disease. Introduction to DNA microarray technology. **(Total Hours: 4)**

Module 4: Structure and Properties of Proteins: Introduction to levels of protein structure: primary, secondary, tertiary, and quaternary. Basic chemical properties of amino acids and proteins. Physical interactions that stabilize protein structure. Common methods for protein size determination: Native PAGE and SDS-PAGE. **(Total Hours: 5)**

Module 5: Introduction to Proteomics: Fundamental goals and scope of proteomics. Concept of proteome analysis. Basic principle and workflow of Two-Dimensional PAGE (2D-PAGE): sample preparation, isoelectric focusing, and SDS-PAGE. Introduction to mass spectrometry as a tool for protein identification. **(Total Hours: 5)**
Module 6: Protein Databases: Introduction to the Protein Data Bank (PDB). Overview of protein sequence databases and secondary resources. Basic concept of transcriptomics and gene expression analysis. Introduction to metabolomics and its role in understanding cellular processes. **(Total Hours: 5)**
Module 7: Introduction to Bioinformatics: History and development of bioinformatics. Importance of bioinformatics in biology and healthcare. Goals and scope of bioinformatics. Relationship between the central dogma of molecular biology and bioinformatics. **(Total Hours: 4)**
Module 8: Data Generation and Data Retrieval: Common sequence file formats: FASTA, GenBank, and EMBL. Introduction to data retrieval using NCBI Entrez. Basic overview of sequence submission tools: BankIt and Sequin. **(Total Hours: 5)**
Module 9: Sequence Alignment: Concept of sequence similarity and its biological significance. Introduction to alignment methods: Dot matrix analysis and BLAST (Basic Local Alignment Search Tool). Difference between local and global alignment. Pairwise and multiple sequence alignment — conceptual understanding. Concept of sequence identity and homology. **(Total Hours: 6)**

Suggested Readings:

1. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.
2. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
3. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
4. David W. Mount. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
5. Voet, Voet and Pratt. Fundamentals of Biochemistry. John Wiley and Sons.

PRACTICAL
Credit: 2
Total Hours: 60
BMBT 7491 – Lab on Bioinformatics

(Wherever computer lab or internet access is not available, the principles and concepts can be demonstrated through any other material or medium including videos, virtual labs, or offline software tools.)

1. **Introduction to Bioinformatics Tools and Databases**
    - Retrieval of biological sequence and structural data from NCBI GenBank, UniProt, and PDB databases.
    - Navigation and data extraction using NCBI Entrez search tools.
    - Understanding accession numbers, sequence annotations, and database records.
2. **Sequence File Formats and Data Submission Tools**
    - Study and comparison of FASTA, GenBank, and EMBL file formats.
    - Creation of FASTA files and interpretation of GenBank/EMBL records.
    - Introduction to sequence submission workflow using NCBI BankIt.
3. **Pairwise Sequence Alignment Using BLAST**
    - Sequence similarity searching using NCBI BLAST.
    - Use of BLASTn and BLASTp programs.
    - Interpretation of E-values, bit scores, percent identity, and query coverage.
4. **Visualisation of Protein 3D Structures Using Ras Mol**
    - Download and visualization of protein structures from PDB.
    - Exploration of different molecular display modes (wireframe, backbone, ribbon, cartoon, space-fill).
    - Identification of secondary structural elements such as α-helices and β-sheets.
5. **Multiple Sequence Alignment Using Clustal W / Clustal Omega**
    - Alignment of homologous nucleotide or protein sequences.
    - Comparison of Clustal W and Clustal Omega outputs.
    - Identification of conserved residues and biologically significant regions.

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Course Name: Bioprocess, Pharmaceutical and Industrial Biotechnology **Code: BMBT 7402**
Credits: 3 **Modes: Offline**
Total hours: 45 hrs

Aim of the course: This course provides a comprehensive understanding of the fundamental principles and applications of bioprocess engineering, pharmaceutical biotechnology, and industrial biotechnology. It bridges the gap between laboratory-scale biology and large-scale industrial processes, covering bioreactor design, upstream and downstream processing, production of biopharmaceuticals, and industrial products such as enzymes, organic acids, and biofuels.

Course objectives: The objectives of this course are to introduce students to the key principles of bioprocess engineering including microbial growth kinetics, bioreactor design, and upstream/downstream processing. Students will analyze industrial production processes for major biopharmaceuticals, evaluate biotechnology applications in industrial sectors, and recognize the importance of GMP, quality control, and regulatory frameworks. By the end of the course, students should be able to design a basic bioprocess flow diagram for a given product and appreciate current trends in biomanufacturing.

Sl	Graduate Attributes	Mapped Modules
CO1	Explain the fundamental principles of bioprocess engineering, including microbial growth kinetics, the operation of various bioreactor types, and key upstream/downstream processing techniques.	M1
CO2	Analyze the industrial production processes for key biopharmaceuticals like antibiotics, recombinant proteins, and vaccines, considering GMP and regulatory requirements.	M2
CO3	Evaluate strategies for industrial production of enzymes, organic acids, and biofuels, and propose their applications in different industrial sectors.	M3
CO4	Differentiate between the manufacturing processes of innovator biologics and biosimilars, identifying their regulatory and technical challenges.	M2, M4
CO5	Design a basic bioprocess flow diagram for a given product incorporating upstream, fermentation, and downstream unit operations.	M1, M3
CO6	Recognize the importance of Good Manufacturing Practices (GMP), quality control, and regulatory frameworks (FDA, EMA, CDSCO) in biopharmaceutical manufacturing.	M2, M4

Learning Outcome/Skills: To impart basic knowledge about the following

- Understand the key principles of bioprocess engineering including microbial growth kinetics, sterilization, and monitoring of bioreactor parameters.
- Describe the design and operation of various types of bioreactors and explain upstream and downstream processing strategies.
- Explain the industrial production processes for major biopharmaceuticals including antibiotics, recombinant proteins, and vaccines.
- Recognize the role of GMP, GLP, and regulatory bodies (FDA, EMA, CDSCO) in ensuring quality and safety of biopharmaceuticals.
- Evaluate strategies for industrial production of enzymes, organic acids, and biofuels using microbial fermentation.

- Differentiate between first, second, and third-generation biofuels and describe their production processes.
- Understand the concept of biosimilars and their regulatory approval pathway compared to innovator biologics.
- Appreciate emerging trends in bioprocess intensification including continuous biomanufacturing, single-use systems, and AI-driven optimization.
- Recognize key industrial safety practices including HACCP, biosafety levels, and management of industrial effluents.
- Develop the ability to design a simple bioprocess flow diagram incorporating upstream, fermentation, and downstream unit operations.

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
THEORY						
M1	**Fundamentals of Bioprocess Engineering**	Introduction to Bioprocess Technology; Bioreactor Design and Operation; Upstream Processing; Downstream Processing; Introduction to Process Analytical Technology (PAT)	12	30%	2, 3, 4	Core engineering principles
M2	**Pharmaceutical Biotechnology**	Production of Biopharmaceuticals; Industrial Production of Antibiotics, Recombinant Proteins and Vaccines; Quality Assurance and Regulatory Affairs (GMP, GLP, FDA, EMA, CDSCO)	12	30%	2, 3, 4	Pharmaceutical applications
M3	**Industrial Biotechnology**	Industrial Enzymes; Bioproduction of Organic Acids and Solvents; Biofuel Technology (1st, 2nd, 3rd generation)	10	20%	3, 4	Industrial applications
M4	**Emerging Trends and Industrial Safety**	Bioprocess Intensification; Biosimilars; Industrial Safety and Waste Management (HACCP, biosafety, effluent treatment)	11	20%	3, 4, 5	Emerging and safety aspects
Total Theory			**45**	**100**		

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Detailed Syllabus

Module 1: Fundamentals of Bioprocess Engineering: (Total Hours: 12)

Introduction to Bioprocess Technology: Historical development, scope, and key principles. Overview of microbial growth kinetics (batch, fed-batch, continuous culture). Bioreactor Design and Operation: Types of bioreactors (stirred-tank, airlift, bubble column, packed bed). Basic design considerations, sterilization of bioreactor and media, monitoring and control of parameters (pH, temperature, dissolved oxygen, foam). Upstream Processing: Media formulation, inoculum development, and scale-up strategies. Downstream Processing: Cell harvest and disruption, solid-liquid separation (filtration, centrifugation), product purification (precipitation, chromatography, membrane filtration), concentration and formulation (drying, lyophilization). Introduction to the concept of Process Analytical Technology (PAT).

Module 2: Pharmaceutical Biotechnology: (Total Hours: 12)

Production of Biopharmaceuticals: Host systems for recombinant protein production (E. coli, yeast, mammalian cell cultures – CHO cells). Regulatory requirements for cell line development. Industrial Production of Major Biopharmaceuticals: Antibiotics: Production of penicillin and streptomycin; strain improvement; downstream processing. Recombinant Proteins: Case studies of insulin, human growth hormone, and monoclonal antibodies (mAbs) – including upstream and downstream challenges. Vaccines: Production of traditional (inactivated/attenuated) and modern (recombinant subunit, DNA, viral vector) vaccines, e.g., Hepatitis B vaccine production in yeast. Quality Assurance and Regulatory Affairs: Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP). Introduction to regulatory bodies (USFDA, EMA, CDSCO). Quality control tests for biopharmaceuticals (potency, purity, sterility, endotoxin testing).

Module 3: Industrial Biotechnology: (Total Hours: 10)

Industrial Enzymes: Sources (microbial, plant, animal) and production methods (submerged and solid-state fermentation). Strategies for enzyme recovery and purification. Applications in food, detergent, textile, pulp and paper, and leather industries (e.g., proteases, amylases, lipases, cellulases, pectinases). Bioproduction of Organic Acids and Solvents: Industrial production of citric acid, lactic acid, and acetic acid. Acetone-butanol-ethanol (ABE) fermentation. Biofuel Technology: First, second, and third-generation biofuel production. Bioprocess for ethanol production from sugarcane and lignocellulosic biomass. Biodiesel production via transesterification and bio-hydrogen production.

Module 4: Emerging Trends and Industrial Safety: (Total Hours: 11)

Bioprocess Intensification: Continuous biomanufacturing, single-use bioreactors, and the role of automation and artificial intelligence in bioprocessing. Biosimilars: Concept, regulatory pathway, and manufacturing challenges compared to innovator biologics. Industrial Safety and Waste Management: Hazard analysis and critical control points (HACCP). Biosafety levels and containment practices. Treatment of industrial effluents from bioprocessing units.

Suggested Readings:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. Principles of Fermentation Technology (3rd ed.). Elsevier.
2. Shuler, M. L., & Kargi, F. Bioprocess Engineering: Basic Concepts (3rd ed.). Prentice Hall.
3. Walsh, G. Pharmaceutical Biotechnology: Concepts and Applications. John Wiley & Sons.
4. Crueger, W., & Crueger, A. Biotechnology: A Textbook of Industrial Microbiology (2nd ed.). Panima Publishing.
5. Ratledge, C., & Kristiansen, B. (Eds.). Basic Biotechnology (3rd ed.). Cambridge University Press.
6. Niazi, S. K. Handbook of Pharmaceutical Manufacturing Formulations. CRC Press.
7. Vogel, H. C., & Todaro, C. M. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment (3rd ed.). Elsevier.

PRACTICAL
Credit: 2
Total Hours: 60
BMBT 7492 – Bioprocess, Pharmaceutical and Industrial Biotechnology Lab

(Wherever computer lab or internet access is not available, the principles and concepts can be demonstrated through any other material or medium including videos, virtual labs, or offline software tools.)

Unit 1: Bioprocess Engineering Basics

- Media preparation and sterilization: Preparation of complex and synthetic media for bacterial/fungal cultivation. Sterilization by autoclaving and membrane filtration.
- Inoculum development: Preparation of seed culture from a lyophilized or stock culture; determining viable cell count (CFU/mL) and optical density (OD) for standardized inoculum.
- Growth curve analysis: Batch cultivation of *E. coli* or *S. cerevisiae* in shake flasks; measurement of growth by turbidometry and dry weight method; plotting and interpretation of growth phases.
- Batch fermentation in a bench-top bioreactor (demonstration): Assembly, sterilization, inoculation, and monitoring of parameters (pH, temperature, DO). Sampling and analysis of biomass and product.

Unit 2: Downstream Processing

- Cell harvesting and disruption: Separation of biomass by centrifugation and microfiltration. Cell disruption by sonication or bead milling. Verification of disruption by microscopy or protein release assay.
- Protein precipitation and dialysis: Ammonium sulfate precipitation of a model protein (e.g., BSA or crude enzyme extract). Desalting and buffer exchange by dialysis. Protein estimation by Bradford or Lowry method.
- Aqueous two-phase extraction: Separation of a model protein or enzyme using PEG-salt or PEG-dextran system. Partition coefficient determination.

Unit 3: Pharmaceutical Biotechnology

- Assay for antibiotic activity: Production of penicillin or streptomycin by *Penicillium* or *Streptomyces* in shake flask. Extraction and bioassay by agar well diffusion or disc diffusion method against a sensitive test organism.
- Simulated monoclonal antibody purification (demonstration or micro-scale): Affinity purification using Protein A column (simulated with commercial IgG). Analysis by SDS-PAGE.
- Endotoxin testing (LAL test): Demonstration of Limulus Amebocyte Lysate (LAL) gel clot method for detection of bacterial endotoxins in a sample.

Unit 4: Industrial Biotechnology

- Production of citric acid: Submerged fermentation by *Aspergillus niger*. Titrimetric determination of citric acid produced.
- Enzyme production and assay: Production of amylase or protease by *Bacillus* sp. Assay of enzyme activity (starch-iodine method for amylase; casein digestion for protease). Effect of pH and temperature on enzyme activity.
- Enzyme immobilization: Immobilization of enzyme (e.g., invertase, amylase) by entrapment in calcium alginate beads. Comparison of activity of free vs. immobilized enzyme.
- Bioethanol production demonstration: Small-scale fermentation of molasses or fruit waste by *Saccharomyces cerevisiae*. Distillation and estimation of alcohol by specific gravity or dichromate method.

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Course Name: Research Methodology **Code: BMBT 7403**
Credits: 3L + 1T **Modes: Offline**
Total hours: 60 hrs

Aim of the course: The course aims to provide students with a comprehensive understanding of research methodology and biostatistics in the field of Biotechnology. It is designed to develop the knowledge and practical skills required for conducting scientific research, analyzing data, and communicating research findings ethically and effectively.

Course objectives: This course aims to provide students with a comprehensive understanding of research methodology and its applications in Biotechnology. It focuses on developing skills in research design, data collection, statistical analysis, and scientific report writing while emphasizing research ethics and academic integrity. The course also enables students to apply research principles in laboratory practice, critically evaluate scientific literature, and understand the processes involved in research funding, publication, and peer review.

Sl	Graduate Attributes	Mapped Modules
CO1	To familiarize students with the fundamental concepts, types, and applications of research in Medical Laboratory Technology.	M1
CO2	To develop skills in identifying research problems, conducting literature reviews, formulating hypotheses, and designing research studies.	M2
CO3	To enable students to apply appropriate sampling methods, data collection techniques, and basic biostatistical tools for research analysis.	M3
CO4	To train students in the preparation of research reports, abstracts, and scientific manuscripts using standard referencing styles and ethical research practices.	M4
CO5	To provide insight into scientific publication processes and the application of research in laboratory disciplines such as pathology, microbiology, biochemistry, and quality assurance.	M5

Learning Outcome/Skills: To impart basic knowledge about the following

- Understand the fundamental concepts, objectives, types, and significance of research, particularly in the field of Biotechnology, while adhering to principles of research ethics and academic integrity.
- Identify research problems, conduct literature reviews, formulate hypotheses, and design scientifically valid research studies using appropriate variables, sampling techniques, and study plans.
- Develop skills in collecting, organizing, and analyzing qualitative and quantitative data using standard data collection methods and basic biostatistical tools, including software such as MS Excel and SPSS.
- Interpret research findings, prepare scientific reports, dissertations, abstracts, and research proposals, and apply standard referencing styles such as Vancouver and APA.
- Apply research methodologies in laboratory disciplines including pathology, microbiology, biochemistry, and quality assurance, and understand the processes involved in research funding, scientific publication, peer review, and manuscript submission.

- Demonstrate the ability to critically evaluate scientific literature, conduct evidence-based investigations, and contribute effectively to research and innovation in healthcare and laboratory sciences.

- Acquire professional competencies in scientific communication, data management, ethical research practices, and publication strategies necessary for academic, clinical, and industrial research

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
THEORY						
1	**Module 1**	**Introduction to Research and its Importance -** Definition and objectives of research. Types of research: Basic, Applied, Clinical, Descriptive, Analytical. Research in Medical Laboratory Technology. Identifying research problems. Review of literature and its significance. Research ethics and plagiarism	10	10%	1,2	NA
2	**Module 2**	**Research Design and Planning -** Elements of a research design. Formulation of hypothesis. Variables: Independent, Dependent, Confounding. Sampling techniques: Probability and Nonprobability. Inclusion and exclusion criteria. Sample size determination. Pilot studies	12	20%	1, 2	NA
3	**Module 3**	**Data Collection and Analysis -** Types of data: Primary vs Secondary, Qualitative vs Quantitative. Data collection methods:	12	20%	1,2, 3	NA

		Surveys, Questionnaires, Observations, Lab data. Tools and instruments used in data collection. Introduction to biostatistics: Mean, Median, Mode, Standard deviation. Data presentation: Tables, Charts, Graphs. Use of Excel/SPSS for data entry and basic analysis **(Total Hours: 12)**				
4	**Module 4**	**Interpretation and Report Writing -** Interpretation of results. Discussion and conclusion. Limitations of the study. Referencing styles: Vancouver, APA. Structure of research reports, dissertations, and articles. Writing abstracts and proposals.	14	30%	1,2, 3	NA
5	**Module 5**	**Research in Laboratory Practice and Publication.** Clinical case study-based research. Research applications in pathology, microbiology, and biochemistry. Quality assurance and control as research. ICMR and other funding agencies. Steps in publication: Selection of journals, peer-review process. Common reasons for manuscript rejection **(Total Hours: 12)**	12	20%	1, 2,3	NA
Total Theory			**60**	**100**		

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Detailed Syllabus

Module 1: Introduction to Research and its Importance - Definition and objectives of research. Types of research: Basic, Applied, Clinical, Descriptive, Analytical. Research in Medical Laboratory Technology. Identifying research problems. Review of literature and its significance. Research ethics and plagiarism **(Total Hours: 10)**
Module 2: Research Design and Planning - Elements of a research design. Formulation of hypothesis. Variables: Independent, Dependent, Confounding. Sampling techniques: Probability and Nonprobability. Inclusion and exclusion criteria. Sample size determination. Pilot studies **(Total Hours: 12)**
Module 3: Data Collection and Analysis - Types of data: Primary vs Secondary, Qualitative vs Quantitative. Data collection methods: Surveys, Questionnaires, Observations, Lab data. Tools and instruments used in data collection. Introduction to biostatistics: Mean, Median, Mode, Standard deviation. Data presentation: Tables, Charts, Graphs. Use of Excel/SPSS for data entry and basic analysis **(Total Hours: 12)**
Module 4: Interpretation and Report Writing - Interpretation of results. Discussion and conclusion. Limitations of the study. Referencing styles: Vancouver, APA. Structure of research reports, dissertations, and articles. Writing abstracts and proposals. **(Total Hours: 14)**
Module 5: Research in Laboratory Practice and Publication. Clinical case study-based research. Research applications in pathology, microbiology, and biochemistry. Quality assurance and control as research. ICMR and other funding agencies. Steps in publication: Selection of journals, peer-review process. Common reasons for manuscript rejection **(Total Hours: 12)**

Suggested Readings:

1. Kothari C. R. and Garg G. (2019) *Research Methodology: Methods and Techniques*. 4th Edition. New Age International Publishers.
2. Creswell J. W. (2018) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 5th Edition. Sage Publications.
3. Ary D. and Jacobs L. C. (2018) *Introduction to Research in Education*. 9th Edition. Cengage Learning.