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

SEVENTH SEMESTER

Course Name: Bioinformatics **Code: BMMC 7401**
Credits: 3 **Modes: Offline**
Total hours: 45 hrs

Aim of the course: This course aims to introduce students of Genetics to the fundamental concepts and tools of bioinformatics. It focuses on building practical skills in accessing biological databases, performing sequence analysis, and understanding how computational approaches are applied in biological research.

Course objectives: This course is designed to provide students with a working knowledge of bioinformatics as applied to genetics. Students will learn to navigate biological databases, understand sequence formats, perform basic sequence alignments, and use tools such as BLAST and ClustalW. The course also introduces pattern recognition, motif analysis, and the relevance of bioinformatics in genomic and genetic research. By the end, students should be able to retrieve, analyse, and interpret biological sequence data using standard bioinformatics tools.

Sl	Graduate Attributes	Mapped Modules
CO1	Describe the history, scope, and importance of bioinformatics and relate it to the central dogma of molecular biology.	M1
CO2	Identify and use major biological databases (NCBI, GenBank, EMBL, UniProt, PDB) for retrieving biological sequence and structural information.	M2
CO3	Explain common sequence file formats and describe the process of sequence data submission to international databases.	M3
CO4	Perform basic sequence similarity searches using BLAST, and distinguish between local and global alignment approaches.	M4
CO5	Understand the concept of multiple sequence alignment and construct basic phylogenetic trees using distance-based methods.	M5
CO6	Navigate key genomic databases and use genome browser tools for accessing and interpreting genomic information.	M6
CO7	Describe the concept of sequence motifs, use motif databases, and understand the basics of gene finding.	M7
CO8	Appreciate the applications of bioinformatics in microbiology, genetics, and disease research.	M8

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

- Explain the significance of bioinformatics and its relationship to the central dogma.
- Access and retrieve data from major biological databases including NCBI, GenBank, EMBL, and UniProt.
- Understand and use common biological sequence file formats.
- Perform pairwise sequence alignment and use BLAST for similarity searching.

- Understand multiple sequence alignment and construct simple phylogenetic trees.
- Navigate genomic databases and genome browsers for accessing genetic information.
- Identify sequence motifs and understand pattern-based approaches to gene finding.
- Appreciate the practical applications of bioinformatics in microbiology and genetics research.

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
THEORY						
M1	**Introduction to Bioinformatics**	History and development of bioinformatics; Importance in biology and healthcare; Goals and scope; Central dogma and bioinformatics	5	12%	1, 2	Conceptual foundation
M2	**Biological Databases**	Introduction to biological databases; Primary vs. secondary databases; NCBI, GenBank, EMBL, UniProt, PDB; Data retrieval using NCBI Entrez	5	12%	1, 2	Database literacy
M3	**Sequence Submission and File Formats**	Sequence submission tools (BankIt, Sequin); Sequence file formats (FASTA, GenBank, EMBL, Swiss-Prot); Concept of INSDC	5	8%	1, 2	Practical data handling
M4	**Sequence Alignment**	Concept of sequence similarity and homology; Dot matrix analysis; BLAST algorithm; Local vs. global alignment; Pairwise alignment	10	20%	1, 2, 3	Core topic; high weightage
M5	**Multiple Sequence Alignment and Phylogenetics**	Concept of multiple sequence alignment; ClustalW; Introduction to phylogenetics; Distance-based methods; Phylogenetic trees	6	16%	1, 2, 3	Comparative analysis skills
M6	**Genomic**	Web-based genomic	5	12%	1, 2	Applied

	Databases and Tools	resources: NCBI, GenBank, EMBL; Basic concept of INSDC; Model organism databases; Introduction to genome browsers				database use
M7	**Pattern Analysis and Motif Finding**	Concept of sequence patterns and motifs; Consensus sequences; Introduction to PROSITE and Pfam; Basic idea of gene finding	5	12%	1, 2	Pattern recognition basics
M8	**Applications of Bioinformatics**	Bioinformatics in drug discovery; Sequence-based disease analysis; Role of bioinformatics in microbiology and genetics; Overview of functional genomics	4	8%	1, 2	Applied awareness
Total Theory			**45**	**100**		

Detailed Syllabus

M1: Introduction to Bioinformatics: History and development of bioinformatics. Importance of bioinformatics in the fields of biology and healthcare. Goals and scope of bioinformatics. Relationship between the central dogma of molecular biology and bioinformatics. **(Total Hours: 5)**

M2: Biological Databases: Introduction to biological databases. Types of databases: primary and secondary. Overview of major databases: NCBI, GenBank, EMBL, UniProt, and Protein Data Bank (PDB). Data retrieval using NCBI Entrez. Introduction to sequence file formats: FASTA, GenBank, and EMBL. **(Total Hours: 5)**

M3: Sequence Submission and File Formats: Sequence submission tools: BankIt and Sequin. Common sequence file formats: flat file, FASTA, GenBank, GenPept, EMBL, and Swiss-Prot. Concept of INSDC (International Nucleotide Sequence Database Collaboration) and its member databases. **(Total Hours: 5)**

M4: Sequence Alignment: Concept of sequence similarity and its biological significance. Difference between sequence identity and homology. Alignment methods: Dot matrix analysis and BLAST (Basic Local Alignment Search Tool). Difference between local and global alignment. Pairwise sequence alignment — conceptual understanding. Introduction to the scoring of alignments. **(Total Hours: 10)**

M5: Multiple Sequence Alignment and Phylogenetics: Concept of multiple sequence alignment (MSA). Introduction to ClustalW for MSA. Basic idea of phylogenetic analysis. Distance-based approaches to phylogeny: UPGMA and Neighbour-Joining methods. Concept of phylogenetic trees:

nodes, branches, clades. Basic interpretation of a phylogenetic tree. **(Total Hours: 6)**
M6: Genomic Databases and Tools: Introduction to web-based genomic resources: NCBI Genome, GenBank, and EMBL. Basic concept of INSDC. Overview of selected model organism genomes and databases. Introduction to genome browsers: basic navigation of NCBI genome browser. **(Total Hours: 5)**
M7: Pattern Analysis and Motif Finding: Concept of sequence patterns and motifs. Representation of motifs: consensus sequences and regular expressions. Introduction to motif databases: PROSITE and Pfam. Basic concept of gene finding: composition-based and motif-based approaches. Introduction to regulatory sequence identification. **(Total Hours: 5)**
M8: Applications of Bioinformatics: Role of bioinformatics in drug discovery and disease research. Application of sequence analysis in understanding microbial genomes. Bioinformatics tools relevant to genetics research. Overview of functional genomics: what genes do and how bioinformatics helps interpret this. Brief introduction to systems biology. **(Total Hours: 4)**

Suggested Readings:

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.
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. Lesk A. M. (2014) Introduction to Bioinformatics. IV Edition. Oxford University Press.

PRACTICAL
Credit: 2
Total Hours: 60
BMMC 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** (4 Hours)
    - 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** (3 Hours)
    - 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** (4 Hours)
    - 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** (4 Hours)
    - 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** (4 Hours)
    - Alignment of homologous nucleotide or protein sequences.
    - Comparison of Clustal W and Clustal Omega outputs.
    - Identification of conserved residues and biologically significant regions.
6. **Phylogenetic Tree Construction Using Clustal Omega, MEGA, and T-Coffee** (6 Hours)
    - Multiple sequence alignment for phylogenetic analysis.
    - Construction of Neighbour-Joining and Maximum Parsimony trees using MEGA.
    - Comparison of phylogenetic trees and interpretation of evolutionary relationships using bootstrap values.
7. **Motif Identification and Pattern Analysis Using PROSITE and MEME** (5 Hours)
    - Identification of conserved functional motifs using PROSITE.
    - De novo motif discovery using MEME.
    - Biological interpretation of conserved sequence patterns and motifs.

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

Course Name: Advanced Diagnostic Approaches for Microbial Disease Detection

Code: BMMC 7402

Credits: 4L + 1T **Modes: Offline**

Total hours: 75 hrs (Theory)

Aim of the course: This course provides an advanced, research-oriented understanding of modern diagnostic techniques for detecting bacterial, viral, fungal, and parasitic infections. It integrates conventional methods with cutting-edge molecular, immunological, point-of-care, and bioinformatic technologies. Emphasis is placed on the principles, applications, and interpretation of techniques such as real-time PCR, isothermal amplification, CRISPR-based diagnostics, next-generation sequencing (NGS), metagenomics, MALDI-TOF MS, and biosensors. For Honours with Research students, the course includes a guided research project leading to a written dissertation.

Course Objectives: The objectives of this course are to understand the limitations of conventional diagnostic methods and the rationale for advanced techniques; explain the principles of molecular diagnostics (PCR, qPCR, isothermal amplification, NGS, metagenomics) and their application in microbial detection; evaluate the role of immunological (ELISA, lateral flow, chemiluminescence) and proteomic (MALDI-TOF MS) methods in rapid diagnosis; analyze emerging technologies such as CRISPR-Cas based detection, biosensors, and point-of-care devices; apply advanced diagnostic approaches for AMR profiling and outbreak surveillance; and design and execute a small-scale research project.

Sl	Graduate Attributes	Mapped Modules
CO1	Explain the principles and applications of advanced molecular, immunological, and proteomic techniques for microbial detection.	M1, M3 (Units 1, 3)
CO2	Select appropriate diagnostic methods based on clinical presentation, pathogen type, and setting (resource-rich vs. limited).	M1, M2, M3, M4
CO3	Analyze and interpret results from qPCR, NGS, MALDI-TOF, and CRISPR-based assays.	M1, M2, M3, M4
CO4	Evaluate the performance characteristics (sensitivity, specificity, PPV, NPV) of new diagnostic tests.	M4 (Unit 4)
CO5	Design a diagnostic workflow for outbreak investigation, antimicrobial resistance surveillance, or point-of-care testing.	M2, M4
CO6	Design and execute a small-scale research project (in silico or literature-based) in diagnostic microbiology.	Research Component
CO7	Critically assess the ethical, regulatory, and quality assurance aspects of implementing advanced diagnostics in clinical and public health laboratories.	M4, Tutorial

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

- Explain the principles and applications of advanced molecular, immunological, and proteomic techniques for microbial detection.
- Select appropriate diagnostic methods based on clinical presentation, pathogen type, and resource setting.
- Analyze and interpret results from qPCR, NGS, MALDI-TOF, CRISPR-based assays, and biosensors.
- Evaluate the performance characteristics (sensitivity, specificity, predictive values) of new diagnostic tests using appropriate statistical methods.
- Design a diagnostic workflow for outbreak investigation, antimicrobial resistance surveillance, or point-of-care testing.

- Design and execute a small-scale research project (in silico or literature-based) in diagnostic microbiology.
- Critically assess the ethical, regulatory, and quality assurance aspects of implementing advanced diagnostics in clinical and public health laboratories.

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
THEORY						
M1	Molecular Diagnostic Techniques	Nucleic acid extraction and quality control. Conventional PCR, nested PCR, multiplex PCR. Real-time PCR (qPCR) and RT-PCR: principles, probes (SYBR Green, TaqMan), quantification, melt curve analysis. Isothermal amplification: LAMP, RPA, NASBA – principles and applications. Digital PCR (dPCR): principle and utility in low-abundance pathogen detection. Point-of-care molecular tests (GeneXpert, cobas Liat, BioFire FilmArray). Research focus: Designing primers/probes for a target pathogen using NCBI PrimerBLAST.	15	20%	3, 4, 5	Molecular diagnostics
M2	Next-Generation Sequencing (NGS) and Metagenomics	Overview of NGS platforms (Illumina, Ion Torrent, Oxford Nanopore). Targeted amplicon sequencing (16S rRNA, ITS regions, tiling amplicons for viruses). Whole genome sequencing (WGS) for pathogen identification, typing, and resistance gene detection. Metagenomic NGS (mNGS) for direct detection from clinical samples (CSF, blood). Bioinformatics basics: read quality filtering, assembly, alignment, pathogen identification (Kraken2, IDseq, CZ ID). Case study: Using WGS for outbreak investigation (e.g., Listeria monocytogenes, Salmonella).	15	20%	3, 4, 5	NGS and metagenomics
M3	Immunological and Proteomic Methods	Enhanced ELISA formats (sandwich, competitive, chemiluminescent). Lateral flow immunoassays (LFIA) – traditional and advanced (multiplex, quantitative, smartphone-read).	15	20%	3, 4	Immunological and proteomic diagnostics

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
		Immunofluorescence, flow cytometry, and bead-based assays for microbial detection. MALDI-TOF MS: principle, sample preparation, library matching for bacterial/fungal identification; applications in blood cultures and direct specimen testing. Biosensors: electrochemical, optical, piezoelectric, and nanomaterial-based for pathogen detection. Case study: MALDI-TOF for rapid identification of bacteremia isolates.				
M4	Emerging Technologies, AMR Diagnostics, and Quality Assurance	CRISPR-Cas based diagnostics (SHERLOCK, DETECTR, HOLMES): mechanism, multiplexing, and field applications. Microarray and bead-based assays for pathogen and resistance gene detection. Rapid phenotypic AMR tests (Accelerate Pheno, disc diffusion automation, microfluidics). Detection of beta-lactamases (Carba NP, modified Hodge test, lateral flow for KPC/NDM). Genotypic resistance markers: databases (CARD, NDARO), molecular detection. Point-of-care devices for resource-limited settings. Quality control, validation, regulatory aspects (CE-IVD, FDA, CDSCO), and biosafety. Research focus: Comparison of a novel diagnostic method with a gold standard.	15	20%	4, 5, 6	Emerging technologies and AMR
M5	Clinical applications of modern molecular diagnostics	Clinical case studies involving molecular diagnosis of infectious diseases using conventional PCR, multiplex PCR, real-time PCR, digital PCR, and point-of-care molecular platforms, followed by interpretation of amplification plots, melt curves, and gel electrophoresis results. Hands-on exercises in primer and probe design using NCBI Primer-BLAST, evaluation of false-positive and false-negative results, and selection of appropriate	15	20%	4, 5, 6	Tutorial

Sl	Module Number	Content	Total Hours	% of Questions	Bloom Level (applicable)	Remarks, if any
		molecular diagnostic methods. Interpretation of immunological and proteomic diagnostic results, including ELISA, lateral flow immunoassays, flow cytometry, and MALDI-TOF mass spectrometry, with emphasis on diagnostic accuracy, sensitivity, specificity, and clinical decision-making				
Total Theory			**75**	**100**		

Detailed Syllabus

Unit 1: Molecular Diagnostic Techniques: Nucleic acid extraction and quality control. Conventional PCR, nested PCR, multiplex PCR. Real-time PCR (qPCR) and reverse transcription PCR (RT-PCR): principles, probes (SYBR Green, TaqMan), quantification, melt curve analysis. Isothermal amplification: LAMP, RPA, NASBA – principles and applications. Digital PCR (dPCR): principle and utility in low-abundance pathogen detection. Point-of-care molecular tests (GeneXpert, cobas Liat, BioFire FilmArray). Research focus: Designing primers/probes for a target pathogen using NCBI Primer BLAST. **(Total Hours: 15)**

Unit 2: Next-Generation Sequencing (NGS) and Metagenomics: Overview of NGS platforms (Illumina, Ion Torrent, Oxford Nanopore). Targeted amplicon sequencing (16S rRNA, ITS regions, tiling amplicons for viruses). Whole genome sequencing (WGS) for pathogen identification, typing, and resistance gene detection. Metagenomic NGS (mNGS) for direct detection from clinical samples (e.g., cerebrospinal fluid, blood). Bioinformatics basics: read quality filtering, assembly, alignment, pathogen identification (Kraken2, IDseq, CZ ID). Case study: Using WGS for outbreak investigation (e.g., Listeria monocytogenes, Salmonella). **(Total Hours: 15)**

Unit 3: Immunological and Proteomic Methods: Enhanced ELISA formats (sandwich, competitive, chemiluminescent). Lateral flow immunoassays (LFIA) – traditional and advanced (multiplex, quantitative, smartphone-read). Immunofluorescence, flow cytometry, and bead-based assays for microbial detection. MALDI-TOF MS: principle, sample preparation, library matching for bacterial/fungal identification; applications in blood cultures and direct specimen testing. Biosensors: electrochemical, optical, piezoelectric, and nanomaterial-based for pathogen detection. Case study: MALDI-TOF for rapid identification of bacteremia isolates. **(Total Hours: 15)**

Unit 4: Emerging Technologies, AMR Diagnostics, and Quality Assurance: CRISPR-Cas based diagnostics (SHERLOCK, DETECTR, HOLMES): mechanism, multiplexing, and field applications. Microarray and bead-based assays for pathogen and resistance gene detection. Rapid phenotypic AMR tests (Accelerate Pheno, disc diffusion automation, microfluidics). Detection of beta-lactamases (Carba NP, modified Hodge test, lateral flow for KPC/NDM). Genotypic resistance markers: databases (CARD, NDARO), molecular detection. Point-of-care devices for resource-limited settings. Quality control, validation, regulatory aspects (CE-IVD, FDA, CDSCO), and biosafety. Research focus: Comparison of a novel diagnostic method with a gold standard – study design and statistical analysis. **(Total Hours: 15)**

Unit 5: Clinical applications of modern molecular diagnostics: Clinical case studies involving molecular diagnosis of infectious diseases using conventional PCR, multiplex PCR, real-time PCR, digital PCR, and point-of-care molecular platforms, followed by interpretation of amplification plots, melt curves, and gel electrophoresis

results. Hands-on exercises in primer and probe design using NCBI Primer-BLAST, evaluation of false-positive and false-negative results, and selection of appropriate molecular diagnostic methods.Interpretation of immunological and proteomic diagnostic results, including ELISA, lateral flow immunoassays, flow cytometry, and MALDI-TOF mass spectrometry, with emphasis on diagnostic accuracy, sensitivity, specificity, and clinical decision-making. **(Total Hours: 15)**

Suggested Readings:

1. Persing, D. H., et al. (2016). Molecular Microbiology: Diagnostic Principles and Practice (3rd ed.). ASM Press.
2. Tang, Y.-W., & Stratton, C. W. (2021). Advanced Techniques in Diagnostic Microbiology (3rd ed.). Springer.
3. Burnham, C.-A. D., & Carroll, K. C. (2021). Diagnostic Microbiology of the Immunocompromised Host (2nd ed.). ASM Press.
4. de Mello, L. R., & Silva, L. P. (2022). Biosensors for Emerging and Re-emerging Infectious Diseases. Academic Press.
5. Journal of Clinical Microbiology (ASM).
6. Clinical Microbiology Reviews (ASM).
7. The Lancet Infectious Diseases.
8. WHO and CDC guidelines for diagnostic methods (e.g., for tuberculosis, influenza, antimicrobial resistance).
9. Online resources: NCBI GenBank, GISAID, CARD (Comprehensive Antibiotic Resistance Database), PubMLST, ClinVar.

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

Course Name: Research Methodology **Code: BMMC 7403**
Credits:4 **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 Genetics. 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 Genetics. 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 Genetics, 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	12	20%	1,2, 3	NA

		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)**				
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**		

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.