Faculty of Science

Master of Science (M.Sc.)

SUBJECT: MICROBIOLOGY

M.Sc. II Semester

Paper- CC 21

Bioinstrumentation

Course Outcomes

CO. No.	Course Outcomes	Cognitive Level
On completion of this course learners will able to:		
CO 1	To learn history, theoretical basis and applications of latest technologies in the advanced area of microbiology.	U, R
CO 2	To gain fundamental knowledge about the light spectrum, absorption, fluorescence, NMR, mass spectroscopy.	A
CO 3	To acquire knowledge on the different Chromatographic methods for the separation of biological products.	U, A

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	6	40	60	**100**
Practical	4	40	60	**100**
Total	**10**	**200**		

M.Sc. Microbiology, II Semester

S.No.	Course Code	Course Name	Total Marks	Credit(s)	End Semester Exam Marks Max.	End Semester Exam Marks Min.	Internal Marks Max.	Internal Marks Min.
1.	CC-21	Bioinstrumentation	100	6	60	24	40	16
2.	CC-22	Biostatistics and Bioinformatics	100	6	60	24	40	16
3.	PC-21	Practical – I	100	4	60	24	40	16
4.	PC-22	Practical – II	100	4	60	24	40	16
5.	Value-added course (VAC) from /MOOCS, SWAYAM, NPTEL (Microbial Technology, Quality Control, Biosafety and Bioethics.)	100	2	-	-	100	40	

Grand Total: 500 Marks, 22 Credits

Note: As per ordinance of PG program NEP 2020 the Minimum passing marks are 40% of the Maximum marks.

Part A: Introduction

Program- Class: M.Sc. Year: I Semester: II Session: 2025-2026	
Subject: Microbiology	
1 Course Code	**CC-21**
2 Course Title	**BIOINSTRUMENTATION**
3 Course Type	**Core Course**
4 Pre-requisite (If any)	**To study this course a student must have had the subject B.Sc. with Biology.**
5 Course Learning outcomes (CLO)	The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research toolkit better. This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. CLO- The course contents of the course students should be able to: 1. To learn history, theoretical basis and applications of latest technologies in the advanced area of microbiology. 2. To gain fundamental knowledge about the light spectrum, absorption, fluorescence, NMR, mass spectroscopy. 3. To acquire knowledge on the different Chromatographic methods for the separation of biological products.
6 Credit Value	**6**
7 Total Marks	**Max. Marks: 40+60** **Min. Passing Marks: 40**

Part B: Content of the Course

(Total lectures: 6 hours/week per credit · Total lecture hours: 90)

Unit	Topics	No. of Lectures
I	**Principles & Applications of Microscopy** • Light microscopy: bright field, dark field, phase-contrast, fluorescent microscopy, flow cytometry • Electron microscopy: transmission & scanning, confocal microscopy, atomic force microscopy **Activities:** 1. Comparative chart on different microscope types & applications 2. Lab visit to demonstrate electron microscopy, AFM, flow cytometry 3. Discussion on biosafety regulations in the lab	18
II	**Macromolecular Structure Determination** • Basics of X-ray crystallography: symmetry, space groups, unit cells, structure factors, reciprocal lattice, Fourier transform, electron density, phase problem & solutions • Biological applications & interpretation • Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR) **Activities:** 1. Lab visit to demonstrate FTIR & X-ray crystallography 2. Comparative chart preparation on NMR vs ESR 3. Quiz on biological application of ESR	18
III	**Centrifugation & Chromatography** • Centrifugation: principles, types (differential, zonal, density gradient & ultracentrifugation), instrument design & applications • Chromatography: principles & types (partition, absorption, paper, thin-layer, gas, ion-exchange, gel-filtration, affinity chromatography, HPLC) • Theory & biological applications of GC and FPLC **Activities:** 1. Chart on different centrifuge types 2. Visit to scientific labs to observe ultracentrifugation 3. Demonstration of GC and applications	18

Unit	Topics	No. of Lectures
IV	**Immunological Techniques** • Immunoelectrophoresis, immunodiffusion, immunofluorescence • Radioimmunoassay, enzyme-linked immunosorbent assay (ELISA) • Autoradiography: principles, methods of processing & applications	18
Module V	**Basics of radioactive isotopes and decay** • Sample preparation, counting • Safety precautions during handling • Biological applications • Liquid scintillation counter • HPGe detector **Introduction to nanobodies** • Nanobody as a tool for protein structure–function studies • Use of nanobodies for molecular imaging **Microarray** • Theory, principle and applications of PSA (Prostate-Specific Antigen) cum Zeta sizer, CRISPR-CAS, DSC-TGA etc.	

Part C: Learning Resources
Text Books, Reference Books, Other Resources
Suggested Readings

1. Banwell, C., *Fundamentals of Molecular Spectroscopy* (4th Ed.): McGraw Hill, 2017
2. Lakowicz, J. & Joseph, R., *Principles of Fluorescence Spectroscopy* (3rd Ed.): Springer, 2006
3. Valeur, B., *Molecular Fluorescence: Principles and Applications* (2nd Ed.): Wiley, 2013
4. Rupp, B., *Biomolecular Crystallography: Principles, Practice and Application to Structural Biology* (1st Ed.): Garland Science, 2009
5. Wilson, K. & Walker, L., *Principles and Techniques in Practical Biochemistry* (5th Ed.): Cambridge University Press, 2000
6. Dash, U.N., *Textbook of Biophysical Chemistry*: Macmillan Publishers India, 2006
7. Cantor, C.R. & Schimmel, P.R., W.H. Freeman and co. *Biophysical Chemistry: Part 2: Techniques* (1st Ed.), 2008

8. Campbell, I.D., *Biophysical Techniques*: Oxford University Press, 2012
9. Serdyuk, I.N., Zaccai, N.R. & Zaccai, G., *Methods in Molecular Biophysics: Structure, Dynamics, Function*: Cambridge University Press, 2007
10. Chakravarty, R., Goel, S. & Cai, W., "Nanobody: The 'Magic Bullet' for Molecular Imaging," *Theranostics*, 4(4), pp. 386–398, 2014. doi:10.7150/thno.8006
11. Books published by M.P. Hindi Granth Academy, Bhopal

Suggested Equivalent Online Courses

1. NPTEL Module 6 – Spectroscopy
2. Microscopy Principles and Types – Cattheine University
3. NPTEL SEM Course Mod16, Module 03
4. Crystallography Lecture Notes – Jiwaji University
5. Environmental Microbiology Methods (Covenant University)
6. TGA & DSC Analysis Lecture PDF
7. M.P. Hindi Granth Academy Website
8. NPTEL Module 3 – Thermogravimetric Analysis (TGA) & DSC
9. Environmental Microbiology PDF (NPTEL/Other)
10. Other Biophysics & Crystallography/Electrophoresis Course Material PDF (Jiwaji)

Part D : Assessment and Evaluation (Theory)		
Maximum Marks: Continuous Comprehensive Evaluation (CCE): University Exam (UE): Time: **03.00 Hours**		**100** **40** **60**
Internal Assessment: Continuous Comprehensive Evaluation (CCE)	Class Test	**20**
	Assignment/Presentation	**20**
	Total	**40**
External Assessment: University Exam	Section (A) : Three Very Short Questions (50 Words Each)	03 x 02 = 06
	Section (B) : Four Short Questions (200 Words Each)	04 x 08 = 32
	Section (C) : Two Long Questions (500 Words Each)	02 x 11 = 22
	Total	**60**

Part D: Assessment and Evaluation (Theory)		
Maximum Marks **Total** Continuous): 60Comprehensive Evaluation (CCE): University Exam (UE **Duration**: 03.00 Hours		 100 40 60
Internal Assessment Continuous Comprehensive Evaluation	Class Test	**20**
	Assignment / Presentation	**20**
	Total	**40**
External Assessment University Exam	Three Very Short Questions (50 words each)	3 × 2 =6
	Four Short Questions (200 words each)	4 × 8 = 32
	Two Long Questions (500 words each)	2 × 11 = 22

Faculty of Science

Master of Science (M.Sc.)

SUBJECT: MICROBIOLOGY

M.Sc. II Semester

Paper- CC 21

Bioinstrumentation

Practical scheme

Part A: Introduction				
Program-	**Class: M.Sc.**	**Year: I**	**Semester: II**	**Session: 2025-2026**
Subject: Microbiology				

1	**Course Code**	**PC-21**
2	**Course Title**	**Lab work for Bioinstrumentation (Practical-I)**
3	**Course Type**	**Core Course**
4	**Pre-requisite (If any)**	To study this course a student must have had the subject B.Sc. with Biology.
5	**Course Learning outcomes (CLO)**	The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better. This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life- sciences. **CLO-** The course contents of the course students should be able to: - 1. To learn history, theoretical basis and applications of latest technologies in the advanced area of microbiology. 2. To gain fundamental knowledge about the light spectrum, absorption, fluorescence, NMR, mass spectroscopy 3. To acquire knowledge on the different. Chromatographic methods for the separation of biological products.

6	**Credit Value**	**4**	
7	**Total Marks**	**Max. Marks: 40+60**	**Min. Passing Marks : 40**

Part B: Content of the Practical Course

Total numbers of Lectures (in hours per week): 8 hours per week/credit Total Lectures: 120 hours

List of Practicals

1. Study of different morphological and surface features using atomic force microscopy
2. Study of the crystalline information of the sample (either solid or thin film) using X-ray diffraction.
3. Quantification of the metal ion concentrations in aqueous samples using atomic absorption spectroscopy (AAS)/inductively coupled plasma mass spectrometry (ICP-MS).
4. Study of the spectrum of pure and complex samples using mass spectroscopy.
5. Study of the variation of properties of substance with heat using differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA).

Part C: Learning Resources

Text Books, Reference Books, Other resources

Suggested Readings:

1. Banwell, C., Fundamentals of Molecular Spectroscopy (4th Ed.): McGraw Hill. 2017.
2. Lakowicz, J. & Joseph, R., Principles of Fluorescence Spectroscopy (3rd Ed.): Springer. 2006.
3. Valeur, B.,Molecular Fluorescence: Principles and Applications (2nd Ed.): Wiley. 2013.
4. Rupp, B., Biomolecular Crystallography: Principles, Practice and Application to Structural Biology (1st Ed.): Garland Science. 2009.
5. Wilson, K. & Walker, L., Principles and Techniques in Practical Biochemistry (5th Ed.): Cambridge University Press. 2000.
6. Dash, U.N., Textbook of Biophysical Chemistry: Macmillan Publishers India. 2006.
7. Cantor, C.R. Schimmel, P.R., W.H Freeman and Co.Biophysical Chemistry: Part 2: Techniques (1st Ed.): 2008.
8. Campbell, I.D., Biophysical Techniques: Oxford: Oxford University Press. 2012.

9. Serdyuk, I.N., Zaccai, N.R., & Zaccai, G.,. Methods in Molecular Biophysics: Structure, Dynamics, Function: Cambridge: Cambridge University Press. 2007.
10. Chakravarty, R., Goel, S. & Cai, W., Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006. 2014
11. Punt, J., Stranford, S., Jones, P. & Owen, J.A., Kuby Immunology (8th Ed.). Macmillan International Higher Education. 2018.
12. Delves, P.J., Martin, S.J., Burton, D.R. &Roitt, I.M., Roitt's Essential Immunology (13th Ed.). Wiley- Blackwell. 2017.

Part D - Assessment and Evaluation (Practical)	
Scheme of Practical Examination: -	**Max. Marks: 40 +60 =100**
Internal Assessment	**Max. Marks-40**
Class Interaction	10
Quiz	10
Seminar	10
Assignments (Charts, Rural Service, Technology Dissemination/ Excursion/ Lab Visit/Industrial Training	10
External Assessment	**Max. Marks-60**
Major experiment	10
Minor Experiment-1	10
Minor Experiment-2	10
Spotting	10
Viva-Voce	10
Practical Record	10

Faculty of Science

Master of Science (M.Sc.)

SUBJECT: MICROBIOLOGY

M.Sc. II Semester

Paper- CC 22

Biostatistics and Bioinformatics

Course Outcomes

CO. No.	Course Outcomes	Cognitive Level
On completion of this course learners will able to:		
CO 1	Develop an understanding of the basics of biostatistics, data analysis tools and bioinformatics tools;	U, R
CO 2	Gain working knowledge of these bioinformatics tools and methods.	A
CO 3	Appreciate their relevance for investigating specific contemporary biological questions.	U
Co 4	Critically analyze and interpret results of their study.	A

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	6	40	60	**100**
Practical	4	40	60	**100**
Total	**10**	**200**		

M.Sc. Microbiology NEP 2020

M.Sc. Microbiology, II Semester

S.No.	Course Code	Course Name	Total Marks	Credit (s)	End Semester Exam Marks		Internal Marks	
					Max.	Min.	Max.	Min.
1.	CC-21	Bioinstrumentation	100	6	60	24	40	16
2.	CC-22	Biostatistics and Bioinformatics	100	6	60	24	40	16
3.	PC-21	Practical – I	100	4	60	24	40	16
4.	PC-22	Practical – II	100	4	60	24	40	16
5.		Value-added course (VAC) from /MOOCS, SWAYAM, NPTEL (Microbial Technology, Quality Control, Biosafety and Bioethics.	100	2	-	-	100	40
		Grand Total	**500**	**22**				

Note: As per ordinance of PG program NEP 2020 the Minimum passing marks are 40% of the Maximum marks.

Part A: Introduction				
Program-	**Class: M.Sc.**	**Year: I**	**Semester: II**	**Session: 2025-2026**
Subject: Microbiology				

1	**Course Code**	**CC-22**	
2	**Course Title**	**Biostatistics and Bioinformatics**	
3	**Course Type**	**Core Course**	
4	**Pre-requisite (If any)**	**To study this course a student must have had the subject B.Sc. with Biology.**	
5	**Course Learning outcomes (CLO)**	The objectives of this course are to provide basic knowledge about biostatistics and bioinformatics. **CLO-** The students should be able to: - 1. Develop an understanding of the basics of biostatistics, data analysis tools and bioinformatics tools; 2. Gain working knowledge of these bioinformatics tools and methods. 3. Appreciate their relevance for investigating specific contemporary biological questions. 4. Critically analyze and interpret results of their study.	
6	**Credit Value**	**6**	
7	**Total Marks**	**Max. Marks: 40+60**	**Min. Passing Marks: 40**

Part B: Content of the Course		
Total numbers of Lectures (in hours per week) : 6 hours per week/credit Total Lectures : 90 hours		
Unit	**Topics**	**Number of Lectures**
I	**Introduction Concept** of variables in biological systems. Collection, classification, tabulation graphical and diagrammatic representation of numerical data. Measures of central tendency: mean, median and mode and their relationship, measures of dispersion: Range, quartile deviation, mean deviation, standard deviation. Coefficient of variation, skew ness and kurtosis. Probability: Random experiment, events, sample space, mutually exclusive events, independent and dependent events. Various definitions of probability, addition and multiplication theorems of probability (only statement), Random variables (discrete and continuous). Probability density functions and its properties. Activity- 1. Group discussion on importance of Biostatistics with reference to research data. 2. Flow chart on sampling methods and /or Chi-square test and student's 't' test 3. Quiz on databases related to Bioinformatics.	**18**
II	**Sample** Some probability distributions such as binomial, Poisson and normal (Basic idea about these distributions) and their applications. Concept of populations and sample. Simple random sampling without replacement. Definition of simple random sample. Chi-square (X2), student's t and f-distributions (derivations not required) their properties and uses. Concept of standard error. Correlation and Regression, linear and quadratic regression Analysis of variance: One- way and two-way classifications with single observation per cell. Activity- 1. Exercise on probability distributions and Analysis of variance. 2. Field Survey of different types of sampling methods.	**18**
III	**Introduction to Bioinformatics** Definition, role, scope and limitation of Bioinformatics. Different branches of Bioinformatics. Terminologies: Internet Browser, Software, hardware, database, Network NicNet, Inflibnet, EMBnet, Operating System, algorithm. Biological data & databases: Biological data type, Classification of biological database, sequence database: GenBank, EMBLDDBJ, PIR, SWISS-PROT. Secondary nucleotide and protein sequence databases: ExInt, TIGR, EPD, CUTG, GOBASE, PROSITE, PRINTS, BLOCKS, Pfam, PRODOME. Structure database: PDB, CSD, CATH, SCOP, FSSP, Specialized Database: KEGG, ENZYME, REBASE. Study odf data entry formats: GenBank, EMBL, DDBJ, Swiss-Port, PIR, PDB, FASTA, MSA, PHYLIP Activity- 1. Chart preparation of Software and hardware used in	**18**

	bioinformatics. 2. Online exercise on protein sequencing PROSITE, Pfam, PRODOME database. 3. Model preparation on classification sequence database.	
IV	**Sequence Analysis** Introduction, methods (HMM & ANN) and significance. Nucleic acid sequence analysis: Principle and software tools. Protein Sequence Analysis: Principle and software tools. Sequence Comparison: Pair wise algorithms-Introduction and significance. Methods of alignment: Dot matrix, Dynamic Programming, Heuristic algorithm (FASTA & BLAST). Scoring matrix: PAM and BLOSUM, Concept of Gap penalty. Multiple Sequence Alignment Introduction, Significance and various algorithms. Phylogenetic Analysis: Introduction & Importance, Phylogenetic tree, methods of Phylogenetic analysis. Activity- 1. Discussion on Nucleic acid sequence analysis and software tools used. 2. Comparative Chart Preparation on methods of alignment: Dot matrix and Scoring matrix. 3. Quiz on multiple sequence Alignment/ methods of Phylogenetic analysis.	**18**
V	**Structural Bioinformatics** Introduction & Importance. Experimental Structure determination: X-ray, NMR and electron microscopy. Coordinate systems. Visualization & presentation of structure. Geometric Analysis of structure. Structure comparison. Protein structure prediction: secondary structure prediction, tertiary structure prediction. Protein folding. Nucleic acid structure: RNA structure prediction: principle and tools: DNA structural polymorphism. Molecular modeling and dynamics, computer aided drug designing Activity- 1. Questionnaire preparation Geometric Analysis of structure. 2. Online exercise of protein folding. 3. Discussion on computer aided drug designing.	**18**

Part C: Learning Resources

Text Books, Reference Books, Other resources

Suggested Readings:

Statistics:

1. An Introduction Biostatistics Glover
2. Mishra & Mishra An Introduction Biostatistics- , Kalyani Publication .
3. Bajpai P.K. S Chand Biological Instru mentation and Methodology & Company, 2010.
4. K.N. Scott and A.K. MathurTextbook of Biomedical Instrumentation, , CBS Publishers and Distributors Pvt Ltd; 1st Edition,2013.
5. Khan & Khanum Shiba Khan, Fundamentals of Biostatistics Ukaaz Publications,
6. Jayaram Reddy. Bioinformatics and Biostatistics, Jayaram Reddy, Geetha Book House, Bengaluru, 2017
7. Books published by M.P. Hindi Granth Academy, Bhopal.

Suggested equivalent online courses:

1. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202004241216240370priyamka_SDS_COLLECTION_OF_DATA.pdf
2. https://ebooks.inflibnet.ac.in/hsp16/chapter/and-tabulation-of-data/
3. https://egyankosh.ac.in/bitstream/123456789/65182/3/Unit-3.pdf
4. https://digital.nios.ac.in/content/311en/311_Maths_Eng_Lesson18.pdf
5. https://math.ucr.edu/~jbritton/Normal_Binomial_Poisson_Distributions.pdf
6. https://uw.pressbooks.pub/quantbusiness/chapter/simple-linear-regression-and-correlation/
7. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291612341467kuaum_yadav_Bioinformatics.pdf
8. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001174BS/P001209/M014178/ET/1526979884P14_M2_ET.pdf
9. https://www.ebi.ac.uk/training/online/courses/bioinformatics-terrified/what-makes-a-good-bioinformatics-database/primary-and-secondary-databases/
10. http://www.binf.gmu.edu/jafri/binf630/Lecture7.pdf
11. https://www.biogem.org/downloads/notes/kau/PAM%20and%20BLOSUM%20Matrices.pdf
12. https://onlinecourses.nptel.ac.in/noc21_bt29/preview
13. https://liacs.leidenuniv.nl/~bakkerem2/cmb2015/CMB2015_lecture10.pdf
14. http//www.mphindigranthacademy.org

Part D: Assessment and Evaluation (Theory)		
Maximum Marks: Continuous Comprehensive Evaluation (CCE): University Exam (UE): Time: **03.00 Hours**		**100** **40** **60**
Internal Assessment: Continuous Comprehensive Evaluation (CCE)	Class Test	**20**
	Assignment/Presentation	**20**
	Total	**40**
External Assessment: University Exam	Section (A): Three Very Short Questions (50 Words Each)	03 x 02 = 06
	Section (B): Four Short Questions (200 Words Each)	04 x 08 = 32
	Section (C): Two Long Questions (500 Words Each)	02 x 11 = 22
	Total	**60**

Semester II will be of value add courses (VAC-CHM/EESC) comprised of 2 credits, VAC should be taken from the list of courses provided by Higher Education Department NEP 2020 on web portal.

Master of Science (M.Sc.)
SUBJECT: MICROBIOLOGY
M.Sc. II Semester
Paper- CC 22

Biostatistics and Bioinformatics
Practical Scheme

Part A: Introduction				
Program-	**Class: M.Sc.**	**Year: I**	**Semester: II**	**Session: 2025-2026**
Subject: Microbiology				

1	**Course Code**	**PC-22**	
2	**Course Title**	**Lab work for Biostatistics and Bioinformatics (Practical-II)**	
3	**Course Type**	**Core Course**	
4	**Pre-requisite (If any)**	**To study this course a student must have had the subject B.Sc. with Biology.**	
5	**Course Learning outcomes (CLO)**	The objectives of this course are to provide basic knowledge about biostatistics and bioinformatics. **CLO-** The students should be able to: - 1. Develop an understanding of the basics of biostatistics, data analysis tools and bioinformatics tools; 2. Gain working knowledge of these bioinformatics tools and methods. 3. Appreciate their relevance for investigating specific contemporary biological questions. 4. Critically analyze and interpret results of their study.	
6	**Credit Value**	**4**	
7	**Total Marks**	**Max. Marks: 40+60**	**Max. Marks: 40+60**

Part B: Content of the Practical Course

Total numbers of Lectures (in hours per week): 8 hours per week/credit
Total Lectures: 120 hours

List of Practical

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using Clustal W.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Gen scan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deep view/Py Mol.

Part C: Learning Resources

Text Books, Reference Books, Other resources

Suggested Readings:

1. An Introduction Biostatistics Glover
2. Mishra & Mishra An Introduction Biostatistics- , Kalyani Publication .
3. Bajpai P.K. S Chand Biological Instru mentation and Methodology & Company, 2010.
4. K.N. Scott and A.K. MathurTextbook of Biomedical Instrumentation, , CBS Publishers and Distributors Pvt Ltd; 1st Edition,2013.
5. Khan & Khanum Shiba Khan, Fundamentals of Biostatistics Ukaaz Publications,
6. Jayaram Reddy. Bioinformatics and Biostatistics, Jayaram Reddy, Geetha Book House, Bengaluru, 2017.
7. Green, M.R., &Sambrook, J., Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.
8. Mount, D.W., Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2001.
9. Baxevanis, A.D., & Ouellette, B.F., Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. 2001.
10. Pevsner, J., Bioinformatics and Functional Genomics.Hoboken, NJ:Wiley-Blackwell.2015.
11. Bourne,P.E.,& Gu,J. Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.2009.
12. Lesk, A.M., Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. 2004.
13. Books published by M.P. Hindi Granth Academy, Bhopal.

Suggested equivalent online courses:

1. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202004241216240370priyamka_SDS_COLLECTION_OF_DATA.pdf
2. https://ebooks.inflibnet.ac.in/hsp16/chapter/and-tabulation-of-data/
3. https://egyankosh.ac.in/bitstream/123456789/65182/3/Unit-3.pdf
4. https://digital.nios.ac.in/content/311en/311_Maths_Eng_Lesson18.pdf
5. https://math.ucr.edu/~jbritton/Normal_Binomial_Poisson_Distributions.pdf
6. https://uw.pressbooks.pub/quantbusiness/chapter/simple-linear-regression-and-correlation/
7. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291612341467kuaum_yadav_Bioinformatics.pdf
8. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001174BS/P001209/M014178/ET/1526979884P14_M2_ET.pdf
9. https://www.ebi.ac.uk/training/online/courses/bioinformatics-terrified/what-makes-a-good-bioinformatics-database/primary-and-secondary-databases/
10. http://www.binf.gmu.edu/jafri/binf630/Lecture7.pdf
11. https://www.biogem.org/downloads/notes/kau/PAM%20and%20BLOSUM%20Matrices.pdf
12. https://onlinecourses.nptel.ac.in/noc21_bt29/preview
13. https://liacs.leidenuniv.nl/~bakkerem2/cmb2015/CMB2015_lecture10.pdf
14. http//www.mphindigranthacademy.org

Part D - Assessment and Evaluation (Practical)	
Scheme of Practical Examination: -	**Max. Marks: 40 +60 =100**
Internal Assessment	**Max. Marks-40**
Class Interaction	10
Quiz	10
Seminar	10
Assignments (Charts, Rural Service, Technology Dissemination/ Excursion/ Lab Visit/Industrial Training	10
External Assessment	**Max. Marks-60**
Major experiment	10
Minor Experiment-1	10
Minor Experiment-2	10
Spotting	10
Viva-Voce	10
Practical Record	10