Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)
Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For

M.Sc. Microbiology

(Based on NEP 2020 framework)
(To be implemented from the Academic Year 2023-24)

Semester 1 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory Theory (4+2)	23ScMicP111	Major Theory Paper 1	Microbial Taxonomy & Systematics	4	4	50	50	100
	23ScMicP112	Major Theory Paper 2	Instrumentation & Molecular biophysics	2	2	25	25	50
Major Elective Theory (4)	23ScMicP121	Major Elective 1 (Theory)	Biochemistry and Metabolism (Elective)	4	4	50	50	100
	23ScMicP122	Major Elective 2 (Theory)	Cell cytology, Developmental & Communication Biology (Elective)	4				
Major Mandatory Practicals (4+4)	23ScMicP113	Major Practical 1	Practical course I: Based on Microbial Taxonomy & Systematics	8	4	50	50	100
	23ScMicP114	Major Practical 2	Practical course II: Based on Biophysics, Biochemistry & Communication Biology	8	4	50	50	100
RM (4)	23ScMicP131	RM Theory Paper	Research Methodology (Section 1)	2	2	50	50	100
		RM Practical Paper	Research Methodology (Section 2)	4	2			
OJT (4)		–	–	–	–	–	–	–
Total				32	22	275	275	550

Semester 2 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory Theory (4+2)	23ScMicP211	Major Theory Paper 1	Industrial Wastewater Treatment & Management	4	4	50	50	100
	23ScMicP212	Major Theory Paper 2	Quantitative Biology	2	2	25	25	50
Major Electives (4)	23ScMicP221	Major Elective 1 (Theory)	Enzymology, Bioenergetics and Metabolism (Elective)	4	4	50	50	100
	23ScMicP222	Major Elective 2 (Theory)	Microbial Metabolism & Plant Physiology (Elective)	4				
Major Mandatory Theory (4+2)	23ScMicP213	Major Practical 1	Practical course I: Based on Industrial Wastewater Treatment & Quantitative Biology	8	4	50	50	100
	23ScMicP214	Major Practical 2	Practical course II: Based on Enzymology & Metabolism	8	4	50	50	100
RM (4)		–	–	–	–	–	–	–
		–	–	–				
OJT (4)	23ScMicP241	OJT	On Job Training	8	4	50	50	100
Total				32	22	275	275	550

Semester 3 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory Theory (4+4)	23ScMicP311	Major Theory Paper 1	Immunology	4	4	50	50	100
	23ScMicP312	Major Theory Paper 2	Molecular Biology & Biotechnology I	4	4	50	50	100
Major Electives (4)	23ScMicP321	Major Elective 1 (Theory)	Virology (Elective)	4	4	50	50	100
	23ScMicP322	Major Elective 2 (Theory)	Virology & Molecular Biology (Elective)	4				
Major Mandatory Practical (4+2)	23ScMicP313	Major Practical Paper 1	Practical Course I: Based on Immunology, Virology & Pharmaceuticals	8	4	50	50	100
	23ScMicP314	Major Practical Paper 2	Practical Course I: Based on Molecular biology & Microbial technology I	4	2	25	25	50
RP (4)	23ScMicP352	RP	Research Project	8	4	50	50	100
OJT (4)								
Total				28	22	275	275	550

Semester 4 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandator Theory (4+4)	23ScMicP411	Major Theory Paper 1	Pharmaceutical & Medical Microbiology	2	4	50	50	100
	23ScMicP412	Major Theory Paper 2	Molecular Biology & Biotechnology II	2	4	50	50	100
Major Electives (4)	23ScMicP421	Major Elective 1 (Theory)	Microbial Technology (Elective)	4	4	50	50	100
	23ScMicP422	Major Elective 2 (Theory)	Microbial Technology & Pharmaceutical Biology (Elective)	4				
Major Mandatory Practical (4)	23ScMicP413	Major Practical Paper 1	Practical Course I: Based on Molecular biology & Microbial technology II	8	4	50	50	100
RP (4)	23ScMicP452	RP	Research Project	12	6	75	75	150
OJT (4)								
Total				22	22	275	275	550

OJT: On Job Training
RM: Research Methodology
RP: Research Project

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP111
Course Name: Microbial Taxonomy and Systematics

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Basics principles and concepts of microbial systematics, evolution, diversity, and bioinformatics

Course Objectives:

- Understand the theories of microbial evolution.
- Introduce the concept of eukaryotic and prokaryotic species.
- Understand the relationship between microbial diversity and phylogeny.
- Know various principles and concepts in the evolution and diversity of microorganisms.
- Study the bacterial systematics.
- Explore the diversity of unculturable bacteria.
- Study the various methods used in genome sequencing.
- Use of various tools in bioinformatics for the identification of microbes and construction of phylogenetic trees.

Course Outcomes: On completion of the course, student will be able to –

- Define the basic principles and concepts in microbial evolution, diversity, systematics, genome sequencing, and bioinformatics.
- Explain the molecular clock hypothesis as well as the neutral theory of molecular evolution and their application.
- Illustrate the evolutionary process which results in the formation of new species.
- Estimate the diversity of microorganisms in an ecological niche using measures and indices of diversity.
- Understand the concepts of phylogeny, construction, and interpretation of phylogenetic trees, and tree distances.
- Familiar with Bergey's Manuals of systematic and determinative bacteriology as well as various approaches for the classification of bacteria.
- Know the characteristics of unculturable as well as viable but unculturable bacteria.
- Describe the culture-independent methods for the identification of unculturable bacteria.
- Know the methods used for the extraction of DNA from environmental samples and its metagenomic analysis.
- Apply the principles of systematics to characterize the microbiome.
- Elucidate the vectors, enzymes, and recent methods used in genome sequencing and identification of microorganisms.
- Comprehend the basic concepts in bioinformatics such as data, databases, sequences, and sequence analysis tools as well as their use in the identification of microorganisms.

Course Contents:

Unit 1	Microbial Evolution and Diversity	No. of Lectures
	1. Microbial evolution a. Micro- and Macroevolution b. The concept of prokaryotic and eukaryotic species: (biological-, morphological-, evolutionary-, and phylogenetic species concept) c. The neutral theory of molecular evolution d. The molecular clock hypothesis in molecular evolution e. The concept of speciation f. Phylogeny: Phylogenetic tree and its features, tree distances, types of phylogenetic trees, their interpretation, and applications 2. Microbial diversity a. Introduction to microbial diversity: the concept of species richness, abundance, and evenness b. The expanse of microbial diversity c. Biodiversity hotspots: a brief overview d. Measures of diversity: alpha-, beta- and gamma diversity e. Indices of Diversity: Shannon index, Simpson's index of diversity, reciprocal Simpson's index, Shannon-Winner diversity index, Pielou's Evenness index * (*Note: only numerical questions will be asked in the examination)	20
Unit 2	**Bacterial Systematics and Introduction to Bergey's Manuals**	
	1. Systematics of Bacteria a. Characterization b. Classification c. Nomenclature d. Identification e. Application of principles of taxonomy and diversity in the characterization of the microbiome 2. The science of classification a. Taxonomic hierarchy b. Binomial nomenclature c. Dichotomous keys d. Diversity leads to phylogeny 3. Systems of classification: a. The 5-Kingdom classification system b. The 3-Domain classification system 4. Bergey's manuals and the classification of prokaryotes a. Determinative Bacteriology (Phenetic approach) b. Systematic Bacteriology (Phylogenetic approach) c. Polyphasic Approach	10
Unit 3	**Explorations of Unculturable bacteria**	

	1. Unculturable bacteria a. The concept of unculturable bacteria, viable but nonculturable bacteria b. The reasons behind the unculturability of bacteria c. Approaches for the cultivation of unculturable bacteria. d. Identification of uncultivable bacteria. e. Methods of extracting total DNA from environmental sample and its metagenome analysis.	15
Unit 4	**Genome Sequencing and Bioinformatics**	
	1. Characterization of DNA by sequencing a. Vectors and enzymes used in DNA sequencing b. Outlines of techniques used for DNA sequencing i. Dideoxy chain termination sequencing or Sanger sequencing ii. Next-generation sequencing: Pyrosequencing, Ion torrent, nanopore sequencing Illumina Solexa 2. Bioinformatics 1. Basic principles and concepts in bioinformatics: Data, database, biological sequences, sequence alignments, and analysis 2. Introduction to nucleotide databases: Various types of databases based on nature and source of data, their significance 3. Types of sequence alignments i. Local sequence alignment ii. Global sequence alignment iii. Pairwise sequence alignment iv. Multiple sequence alignment 4. BLAST analysis and identification of bacteria	15

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Unit 3 - Explorations of Unculturable bacteria

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Unit 4 - Genome Sequencing and Bioinformatics

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP112
Course Name: Instrumentation and Molecular Biophysics

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course Objectives:

- To enrich students' knowledge related to basic concepts in Instrumentation and Molecular Biophysics
- To inculcate concepts of instrumentation of HPLC, GC, FACS, Mass spectrophotometry and FTIR
- To make students acquainted with the concepts of NMR and X ray crystallography
- To introduce basics on nanotechnology.

Course Outcomes: On completion of the course, student will be able to –

- Understand instrumentation, principle, role and applications of different instruments used in molecular biophysics.
- Interpret data obtained from different biophysical techniques.
- Understand basics of synthesis and characterization of nanoparticles.

Course Contents:

Unit 1	**Chromatography and Spectroscopy**	**No. of lectures**
	1. Chromatography a. Introduction: Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms. b. Principle, components of the instrument, operation, and applications of: Gas chromatography and High- Performance Liquid Chromatography **2. Spectroscopy** a. Introduction: The electromagnetic spectrum, atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. b. Fluorescence spectroscopy: Instrumentation, Quantum yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS c. Infrared spectroscopy: Principle, Instrumentation, Absorption bands, FTIR and its advantages. d. Mass spectroscopy: Principles of operation, Ionization, Ion fragmentation, Mass Analyzers, GC-MS, MALDI-TOF.	15
Unit 2	**X-ray crystallography, NMR and Nanotechnology**	
	1. X-ray crystallography: a. Instrumentation.	15

	b. Crystallization of proteins. c. Basic principles of x-ray diffraction and Acquisition of the diffraction pattern. d. Crystal Structures (Bravais Lattices), Crystal planes, Miller Indices, Direct Lattice and Reciprocal lattice. e. Fourier Transform and Inverse Fourier f. Electron density maps **2. NMR spectroscopy:** a. Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling. b. Nuclear Overhauser Effect Spectroscopy and Correlation Spectroscopy. **3. Brief overview of synthesis and characterization of nanoparticles.**	

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP121
Course Name: Biochemistry and Metabolism (Elective)

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course Objectives:
- To inculcate the basic concepts of biochemistry in the students.
- To teach students about how carbohydrates, proteins, lipids and nucleic acids are metabolized.

Course Outcomes: On completion of the course, student will be able to –
- Understand the basic concepts in biochemistry and metabolism.
- Understand the chemical composition of living system.
- Describe structure and metabolism of carbohydrate
- Explain structure and metabolism of proteins
- Understand structure and metabolism of lipids
- Describe structure and metabolism of nucleic acids.

Course Contents:

Unit 1	**Carbohydrate Chemistry and Metabolism**	**No of Lectures**
	1. Mono, di, oligosaccharides and polysaccharides, with examples 2. Isomerism in sugars: asymmetric centres in sugars, dextro, leavo-rotatory, sugar anomers (reducing and non-reducing sugars), sugar epimers 3. Sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars 4. Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis, 5. Synthesis of microbial exopolysaccharides (alginate) 6. Cellulose synthesis and breakdown 7. Regulation of Glycogen synthesis; breakdown, 8. Metabolic flux and its regulation by various metabolic intermediates 9. TCA cycle- regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle	15
Unit 2	**Lipid Chemistry and Metabolism**	
	1. Classification of lipids according to chemical structure, 2. Fatty acids, saturated, unsaturated, branched, nomenclature system, 3. Structure and function of: triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, and steroids. 4. Synthesis of storage lipids: Fatty acids and triacylglycerols, 5. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols,	15

	6. Degradation of fatty acids (beta oxidation and unsaturated fatty sacid) and fats in animals 7. Lipids as signal molecules (eg phosphatidyl inositol and eicosanoids).	
Unit 3	**Protein Chemistry and Metabolism**	
	1. Henderson Hasselbalch equation and its role in buffer formulation 2. Structural features of amino acids 3. classification of amino acids, 4. amino acids as buffers, 5. chemical reactions of amino acids, peptide linkage, partial double bond nature of peptides, 6. structural classification of proteins : primary, secondary, tertiary, quaternary structures of proteins 7. Overview of amino acid biosynthesis relationship between glycolysis, citric acid cycle, pentose phosphate pathway and various amino acids. 8. Biosynthesis of following amino acid a. Pyruvate family b. α keto glutarate family c. serine family d. aspartate e. aromatic amino acid 9. Importance of glutamine synthetase and it's role in amino acid metabolism. 10. Regulation of amino acid biosynthetic Pathway (aspartate family).	
Unit 4	**Nucleic Acid Chemistry and Metabolism**	
	1. Structure of bases, nucleosides, nucleotides, phospho-diester linkages, 5' phosphate, 3'hydroxyl polarity of nucleic acids, 2. tautomeric forms of bases and their implication in pairing of bases, 3. structure of DNA (A, B and Z forms), 4. Tm value, 5. Structure of t-RNA, r-RNA, and m-RNA. 6. De Novo biosynthesis of purine nucleotide, 7. Salwage pathway 8. De Novo biosynthesis of pyrimidine. 9. Ribonucleotide reductase and its role in nucleic acid metabolism.	15

References

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP122
Course Name: Cell cytology, Developmental and Communication Biology. (Elective)

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course Objectives:

- To inculcate the basic concepts of cell cytology and developmental biology in the students.
- To teach the students the mechanisms of communication and coordination among microorganisms through quorum sensing, biofilms, through the life cycle of *Dictyostelium* and *Myxobacteria*

Course Outcomes: On completion of course students will be able to -

- Understand the basic concepts of cell biology and developmental biology
- Gain basic knowledge about communication biology
- Comprehensive knowledge about life cycle of *Dictyostelium* and *Myxobacteria*
- Understand Quorum sensing Gram-negative and Gram-positive bacteria
- Gain knowledge about Biofilms and its applications.
- Comprehensive knowledge about communication biology in microorganisms

Course Contents

Unit 1	Cell Cytology	No of Lectures
	1. Structural organization and function of eukaryotic cell (Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes), Cytoskeleton and function of molecular motors (Myosin, Kinesin, Dynein) 2. Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes) 3. Cell Cycle and its Regulation, Apoptosis 4. Localization of macromolecules using electron microscopy, Immunoelectron microscopy, and Confocal Microscopy	15
Unit 2	**Developmental Biology**	**15**
	11. Introduction to developmental biology. 12. Different model systems used to study developmental biology a. the fruit fly (*D. melanogaster*), b. nematode (*C. elegans*) c. mouse (*M. musculus*) 13. Conserved nature of development, Concepts of commitment, determination and differentiation 14. Morphogen gradients in developmental regulation, Hox code, MPF 15. Gastrulation and cellular movements involved in it 16. Organizer and its importance giving examples of invertebrates (*Drosophilla*) and vertebrate (*Xenopus*) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity. 17. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; transition to flowering, floral meristems and floral development in *Arabidopsis*.	
Unit 3	**Communication Biology - I**	15
	1. The life cycle of *Dictyostelium discoidum*, 2. Molecular mechanism of quorum sensing in slime molds 3. The life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria	
Unit 4	**Communication Biology - II**	15
	1. Quorum sensing in Gram-positive (*Staphylococcus aureus* virulence fac Gram-negative bacteria (*Vibrio fischeri* lux operon) 2. Biofilms: Their organization, signals involved in biofilm formation and dispersal of biofilms 3. Applications of study on biofilms in pathogens (*Pseudomonas aeruginosa*) and non-pathogenic environments (dental plaque).	

References:

Unit 1: Cell Cytology

- Alberts Bruce (2017). Molecular Biology of Cell.6th edition, Garland Publishing Inc, US
- Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James
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Unit 2: Developmental Biology

- Gilbert Scott F. (2003). Developmental Biology. 7th Edition, Sinauer Associates Inc. Mass. The USA.
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Unit 3: Communication Biology - I

- Gilbert S. F. (2010). Developmental Biology. 9th Ed. Sinauer Associates Inc. Mass. USA.
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Unit 4: Communication Biology - II

- Hamilton W. Allan, (1987). Biofilms: Microbial Interactions and Metabolic activities, in Ecology of Microbial Communities, (Eds. M. Fletcher, T. R. G. Gray, and J. G.Jones) Cambridge University Press, Cambridge.
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- Miller M. B. and Bassler B. L. (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. 55: 165–99.
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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP113
Course Name: Practical course I - Based on Microbial Taxonomy and Systematics

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- Understand media design for isolation of microorganisms from environmental samples.
- Inculcate use of Bergey's manual for identification of microorganisms.
- Understand microbial systematics.

Course outcomes: On completion of the course, student will be able to –

- Use Bergey's manual to create keys for the identification of pure cultures of bacteria. Constructing identification keys for yeasts and molds.
- Develop logic of media designing for isolation of a particular group of microorganisms from a particular environment
- Become competent in various molecular techniques for isolation and purification of chromosomal DNA, use of software in microbial systematics.
- Develop the basic skills required to work in research laboratories working in the field of molecular taxonomy.

Course Contents:

I	**Isolation and identification of bacteria and fungi**	**No. of practicals**
	Isolation of actinomycetes from natural samples and identification to at least genus level	2
	Isolation of thermophiles from natural samples and identification to at least genus level	2
	Isolation of molds from natural samples and identification to at least genus level	2
	Isolation of yeasts from natural samples and identification to at least genus level	2
	Isolation of cyanobacteria from natural samples and identification to at least genus level	2
II	**Molecular Taxonomy**	
	Isolation, purification and checking purity of isolated chromosomal DNA of bacteria	2
	Isolation, purification and checking the purity of total DNA isolated from environmental sample	2
	16S rRNA amplification using PCR, purification of PCR products and determination of molecular weight of PCR products	2
III	**Bioinformatics**	
	Use of nucleotide databases (various databases and features available	2

	on database websites, sequence retrieval, steps in sequence submission to NCBI, reading sequence descriptions)	
	Sequence matching by BLAST analysis.	1
	Phylogenetic tree construction using related sequences	1
*Any 15 practicals from the above list can be conducted.		

References:

Unit I – Isolation and identification of bacteria and fungi

- Breed and Buchanan (1982). Bergey's Manual of Determinative Bacteriology. 9th Edition,
- Breed and Buchanan (2001 –2003). Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5)
- Sykes, G. and F. A. Skinner (Eds) (1973).*Actinomycetales*: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series Academic Press.
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Unit II – Molecular Taxonomy

- Sandy Primrose, Richard Twyman, Bob Old (2001). Principles of Gene Manipulation 6thEdition, Blackwell Science Ltd.
- Sambrook, J., Fritsch, E. F., and Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual, 2ndedition. Cold Spring Harbor: Cold Spring Harbour Laboratory Press
- Ausubel F. M. And Brent R. (1994). Current Protocols in Molecular Biology, John Wiley & Sons Inc, New York

Unit III – Bioinformatics

- URLs:
  - **National Center for Biotechnology Information** www.ncbi.nlm.nih.gov/**Ribosomal Database Project-Release 10** rdp.cme.msu.edu/ **rdp.cme.msu.edu/** seqmatch/**Building phylogenetic trees** **www.itu.dk/~sestoft/bsa**
  - **/dinaws/**phylogeny**.html Reading a Phylogenetic Tree - Nature** www.nature.com//reading-a-**phyloge**

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP114
Course Name: Practical course II - Based on Biophysics, Biochemistry and Communication Biology

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- Know SOP of various instruments.
- Use tools to study Ramachandran plot and protein conformation.
- Understand principle and handling of TLC and ion exchange chromatography.
- Know calculations required for preparation of various solutions and buffers.
- Understand stages of mitosis.
- Explain formation and disruption of biofilms.

Course outcomes: On completion of the course, student will be able to –

- Prepare SOPs for instruments frequently used in biology.
- Prepare buffers, stock and working solutions.
- Interpret Ramachandran plot of a given protein and study its conformation.
- Examine the stages of mitosis from the growing tips of onion root cells.
- Estimate formation and disruption of biofilms.
- Calculate molar extinction coefficient of isolated pigment.
- Separate biomolecules using TLC.
- Determine ion-exchange capacity of a given resin used in ion exchange chromatography.
- Synthesize nanoparticles by biological methods.

Course Contents:

I	**Biochemistry**	**No. of practical**
	Preparation of Percent, Molar, and Normal stock solutions (solid and liquid compounds) and their dilutions to obtain working solutions.	2
	Designing SOP for instruments (autoclave, incubator, spectrophotometer, PCR, pH meter, Incubator shaker, centrifuge, micropipette, hot air oven, weighing balance, laminar air flow hood)	1
	Determination of pKa of a monoprotic weak acid.	1
	Preparation of acidic, basic, and neutral buffers.	1
	Interpretation of Ramachandran Plot and study of conformations of a protein molecule using Molecular Graphics Visualization Tool (e.g., Swiss PDB viewer)	1
II	**Communication biology and Developmental Biology**	
	Observation of stages of mitosis in the growing tip of onion root cells	1
	Demonstration: Observation of mutant strains of *Drosophila*	1
	Isolation of Myxobacteria and observation of fruiting bodies	2

	Crystal violet assay for estimation of biofilm formation	2
	Disruption of biofilm using any chemical/ biological agent	1
III	**Biophysics and Nanotechnology**	
	Separation of sugars by thin layer chromatography and calculation of its Rf value	1
	Separation of amino acids by thin layer chromatography and calculation of its Rf value	1
	Determination of the ion-exchange capacity and nature of given resin using anion exchange chromatography.	2
	Biological synthesis of nanoparticles (actinomycetes /fungi /yeast/ plant extract) and their characterization by UV-Vis spectroscopy.	2
	Isolation of bacterial pigment and its characterization using molar extinction coefficient	3
*Any 15 practicals from the above list can be conducted.		

References:

Unit I - Biochemistry

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- Segel I. H. (2010). Biochemical Calculations, 2nd Edn. India: Wiley India Pvt. Ltd.
- Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
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- Bansal M. and Srinivasan N. (2013). Biomolecular Forms and Functions: A Celebration of 50 Years of the Ramachandran Map. Singapore: World Scientific.
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Unit II - Cell Biology and Developmental Biology

- Manzoor A., Ahmad T., Bashir M. A., Hafiz A. and Silvestri C. (2019). Studies on colchicine induced chromosome doubling for enhancement of quality traits in ornamental plants. Plants.8:194. Doi: 10.3390/plants8070194.
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- Dale K., Mark R. and Lee K. (2010) Myxobacteria, Polarity, and Multicellular Morphogenesis, Cold Spring Harb Perspect Biol 2010; 2: a000380

Unit III - Biophysics and Nanotechnology

- Feldheim D. L. and Foss C. A., Jr. (Editors). (2002) Metal nanoparticles synthesis and characterization and applications. Taylor & Francis
- Hofmann A., Walker J. M., Wilson K. and Clokie S. (2018). Wilson and Walker's Principles and techniques of biochemistry and molecular biology. United Kingdom: Cambridge University Press.
- Mirkin C. A. and Niemeyer C. M. (2006). Nanobiotechnology: Concepts, Applications and Perspectives. Germany: Wiley.
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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP131
Course Name: Research Methodology (Section 1)

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Prerequisite Courses:
- B.A., B.Sc. B.Com, B.Voc., BBA, BBA IB, BBA CA

Course Objectives:
- To make students aware about research and its importance
- To obtain knowledge regarding systematic gathering of data and get advanced knowledge in the selected topic
- To inculcate logical and organized thinking in students
- To investigate some existing situation or problem by creating new system or method
- To help students to design research problem

Course Outcomes: On completion of the course, student will be able to -
- Describe importance of research
- Differentiate between unethical and ethical practices of publication ethics
- Select research problem appropriately
- Prepare good hypothesis
- Design research problem systematically
- Analyze and organize data correctly
- Prepare good scientific research report

Course Contents:

Unit I	**Research problem and design**	**No. of lectures**
	1. **Introduction to research:** meaning and definition of research, objective of research, importance of research, characteristics of good research, purpose and role of research, classification of research. 2. **Research problem:** defining of research problem, Criteria for selecting the research problem, , importance of literature survey in defining research problem. 3. Hypothesis: Defining Hypothesis, types of hypothesis, characteristics of good hypothesis, formulation of hypothesis 4. **Research Design:** Definition and features of research design, Concept of research design, types of research	15

	design, preparation of research design, Sampling techniques, characteristics of good sampling designs	
II	**Data analysis, report writing and publication ethics**	
	1. Definition of Data, methods of data collection, analysis of data, types of data analysis, Questionnaire, Design of Questionnaire, Testing hypothesis : parametric and non-parametric tests : T-test, Z-test, Chi-square test, ANOVA 2. **Report writing** : importance of interpretation of results, meaning, definition and significance of report /thesis writing, Principals of research report drafting, Types of reports, layout of research report, important parts of reports, precautions of preparation of report/ thesis 3. **Publication ethics:** definition, introduction and importance, best practices/ standard settings initiative and guidelines COPE, WAME, etc, conflict of interest, Publication misconduct: definition, concept problems that lead to unethical behavior, violation of publication ethics, predatory publishers and journals, software tools to identify predatory publications developed by SPPU	15

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP131
Course Name: Research Methodology (Section 2)

Teaching Scheme: Practical: 4 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:

- Inculcate research aptitude in students.
- Enhance students' scientific communication skills.
- Familiarize students with design of experiments.

Course outcomes: On completion of the course, student will be able to -

- Learn scientific communication modes like literature review, scientific paper and thesis presentation.
- Use reference management tools and data mining tools.
- Create account on UGC-CARE.
- Write abstract for scientific literature.
- Construct graphical abstract.
- Design experiments using statistical tools.

Course Contents:

I	**Scientific Communication**	**No. of practicums**
	Literature survey, advanced search (PubMed), use of reference manager	1
	Verification of journal indexing opening account at UGC-CARE, Web of Science. Exploring databases (including Scopus, DOAJ) for indexed journals, searching journals, predatory journals, and their directories, retraction database.	1
	Preparing Scientific PowerPoint presentation	1
	Literature Review writing and abstract writing, constructing graphical abstract	2
II	**Design of Experiment**	
	Designing of experiments: completely randomized design, randomized block design, full factorial and fractional factorial designs (Plackett-Burman design)	3

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP211
Course Name: Industrial Wastewater Treatment and Management

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisite Courses:

- Types of water and basic principles as well as concepts related to wastewater treatment.
- General steps involved in the purification of water, generation of sludge and its disposal

Course Objectives:

- Know the sources, characteristics and composition of industrial wastewater.
- Understand the physical, chemical and biological methods used in the industrial wastewater and sludge processing and treatment.
- Learn the measurement of various parameters used for analysis and selection of appropriate method to treat the industrial wastewater.
- Explore various examples of treatment plants used to treat industrial wastewater in various industries

Course Outcomes: On completion of the course, student will be able to –

- Understand the need for treatment of industrial wastewater and its impact on the environment and human health.
- Recognize the sources, characteristics and composition of industrial wastewater.
- Experimental methods used for the measurement of various parameters used to characterize the quality of industrial wastewater at various stages of treatment.
- Know the layout of typical industrial wastewater treatment plant.
- Get acquainted with the strategic use of various unit operations and processes designed for the removal of various micro- and macronutrients present in organic and inorganic compounds, priority pollutants, impurities, contaminants and heavy metals present in industrial wastewater
- Understand the microbiology of various processes. For example, attached and suspended growth processes, aerobic and anaerobic growth processes, etc. and related technologies available to treat the industrial wastewater
- Know various technologies available in industrial wastewater treatment such as preliminary, primary, secondary, tertiary and advanced tertiary treatment
- Analyze the working treatment systems using various critical parameters
- Basic communication with other disciplines to design and construct the industrial wastewater treatment plants.

Course Contents:

Unit 1	Introduction to Industrial Wastewater Treatment	No. of Lectures
	1. The need for industrial wastewater treatment 2. Physical, chemical, microbiological characteristics of wastewater 3. Sampling and analysis of parameters such as BOD, COD, BOD:COD ratio, SVI, TS, TSS, TDS etc. to determine the quality of industrial wastewater * 4. Water quality standards, water pollution control, desirable and permissible limits of constituents for disposal in surrounding water bodies and land 5. Layout of typical wastewater treatment plant (* Note: Only numerical questions should be asked in the examination.)	15
Unit 2	**Physical and Chemical Unit Processes**	**Lectures**
	1. Physical unit operations a. Flow equalization b. Screening c. Flocculation d. Flotation e. Granular medium filtration 2. Chemical unit processes a. Coagulation b. Precipitation c. Neutralization 3. Physical – chemical processes a. Adsorption b. Sedimentation and clarification c. Disinfection	15
Unit 3	**Biological Processes**	**Lectures**
	1. Aerobic processes a. Aerobic digestion b. Activated sludge process c. Aerated lagoons d. Trickling filters e. Nitrification 2. Anaerobic processes a. Anaerobic digestion b. Anaerobic contact process c. Denitrification d. Packed bed reactors e. Biological phosphorus removal 3. Combined processes	18

	a. Trickling filter/solids contact process b. Trickling filter/ activated sludge process c. Series trickling filter, and activated sludge process 4. Working treatment system with reference to activated sludge treatment a. Critical Operating parameters: Dissolved oxygen, Mixed liquor suspended solids (MLSS), Mixed liquor volatile suspended solids (MLVSS), Hydraulic retention time (HRT), mean cell residence time (MCRT), food to Microorganism (F/M) ratio and treatment efficiency. ** (** Note: Only numerical questions should be asked in the examination.)	
Unit 4	**Sludge and Industrial Wastewater Treatment Processes**	**Lectures**
	1. Sludge processing and treatment a. Characteristics of sludge b. Preliminary sludge processing c. Thickening d. Sludge stabilization e. Aerobic and anaerobic digestion of sludge 2. Wastewater treatment processes in various industries a. Dairy industry b. Food processing industry c. Dyeing industry d. Paper and pulp manufacture industry e. Electronic industry	12

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Unit 1: Introduction to Industrial Wastewater Treatment

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23SciMicP212
Course Name: Quantitative Biology

Teaching Scheme: Theory: 2 Hours/Week **Credit: 02**
Examination Scheme: CIA: 25 Marks **End-Sem: 25 Marks**

Course objectives:

- To understand basic concepts in Biostatistics.
- To get acquainted with the concepts of probability distributions and their application.
- To inculcate the concepts of testing hypothesis using parametric and non-parametric tests

Course outcomes: On completion of the course, student will be able to -

- Determine the mean, mode and median of a given data set.
- Understand probability distribution.
- Explain concepts of null and alternate hypothesis, types of errors, level of significance, p value and decision rules
- Set hull hypothesis to a given problem.
- Understand basics concepts and calculations of various parametric and non-parametric tests.
- Apply appropriate statistical test to accept or reject null hypothesis.

Course Contents:

Unit 1	**Basics of statistics**	**No. of lectures**
	1. Probability distribution: Normal (x-scale and z- scale), Binomial and Poisson distributions. 2. Measures of central tendency: Mean Mode, median 3. Measures of dispersion: Mean deviation Standard deviation and Variance 4. The concepts of the null hypothesis, alternate hypothesis, level of significance, p-value, one-tailed and two-tailed tests, type I and type II errors. 5. Distribution of sample means, standard error and confidence interval, degrees of freedom	15
Unit 2	**Parametric and Nonparametric tests (Theory and Numerical)**	**No. of lectures**
	1. Parametric statistical test: a. Z-test b. t-test 2. Comparison of 3 or more samples: a. One way ANOVA and Two way ANOVA 3. Test of Significance: Chi square test (Goodness of fit and Independence)	**15**

	4. Non-parametric tests: a. Kruskal Wallis test b. Sign test c. Wilcoxon's signed rank test d. Mann-Whitney test	

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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP221
Course Name: Enzymology, Bioenergetics and Metabolism (Elective)

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course Objectives:

- To make students learn the principles of enzyme reactions with respect to types, kinetics and coupled reactions.
- To make students understand the Laws of thermodynamics, entropy, enthalpy, free energy, and its significance. with numerical problems
- To teach students how molecules are transported across membrane.
- To teach students biochemistry of aerobic and anaerobic respiration, methanogenesis and photosynthesis

Course Outcomes: On completion of the course, student will be able to -

- Learn about enzyme reactions with respect to its kinetics and coupled reactions.
- Understand the bioenergetics of biological reactions and how the reactions take place inside the cell.
- Interpret the relation between free energy, standard free energy.
- Understand the movement of molecules across the plasma membrane.
- Gain knowledge about signalling pathway in bacteria
- Describe the biochemistry of aerobic and anaerobic respiration, methanogenesis and photosynthesis with various steps involved.

Course Contents:

Unit 1	**Enzymology**	**No of Lectures**
	1. Enzymes: Introduction 2. Kinetics of single substrate enzyme-catalyzed reaction a. MM equation, b. Briggs Haldane equation, c. Lineweaver Burke plot, d. Eadie-Hofstee, e. Hans plot 3. Kinetics of reversible inhibitions enzyme-catalyzed reactions a. competitive inhibition b. non-competitive inhibition, c. uncompetitive inhibition d. Mixed Inhibition 4. Types of two substrate enzyme-catalyzed reactions a. Ping-pong mechanism	15

	b. Random-order mechanism c. Compulsory-order mechanism 5. King Altman approach to derive single substrate and two-substrate enzyme-catalyzed reactions 6. Concept of allosterism, positive and negative cooperativity, models of allosteric enzymes (Monod, Wyman, and Changeux model, Koshland, Nemethy and Filmer model), 7. Kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in allosteric regulation 8. Problems based on calculation of Km and Vmax. Determination of type of enzyme inhibition graphically	
Unit 2	**Bioenergetics**	
	1. Laws of thermodynamics and its significance, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy equation 2. Determination of free energy of hydrolytic and biological oxidation-reduction reactions under standard and non- standard conditions (Problem- solving) 3. High energy compounds 4. Coupled reactions (problem solving) 5. Determination of feasibility of reactions (Problem-solving) 6. Atkinson's energy charge	15
Unit 3	**Membrane transport and signal transduction**	
	1. The composition and architecture of membranes, Membrane dynamics 2. Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases. 3. Ionophores, Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage-gate ion channels. 4. Liposomes and model membranes 5. Signal transduction pathways in bacteria, second messengers, regulation of signalling pathways, bacterial two-component systems, chemotaxis.	15
Unit 4	**Respiration and Photosynthesis**	
	1. Respiration a. Aerobic respiration: Mitochondrial electron transport chain, structure and function of ATPase, generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors of electron transport chain and un-couplers of chemiosmotic coupling. b. Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfur compounds and nitrate as an electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis. 2. Photosynthesis a. Structure of chloroplast, Light Absorption, light and dark reaction, electron carriers in photosynthesis	15

	b. Organization of photosystem I and II, the cyclic and non- cyclic flow of electrons, Hill reaction, photolysis of water c. C3, C4 CAM plants, Photorespiration, Regulation of photosynthesis d. Photosynthesis in bacteria	

References

Unit 1: Enzymology

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Unit 2: Bioenergetics

- Garrett, R. H., & Grisham, C. M. (2010). Biochemistry. 4th edition, Belmont, CA: Brooks/Cole, Cengage Learning.
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Unit 3: Membrane transport and signal transduction

- Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. (2015). Biochemistry. 8th edition,New York: W.H. Freeman.
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Unit 4: Respiration and Photosynthesis

- Madigan M.T., Martinko J.M., Stahl D.A., Clark D.P (2012). Brock Biology of Microorganisms, 13thedition, Benjamin Cummings, San Francisco.
- Moat, A. G., Foster, J. W., & Spector, M. P. (2002). Microbial physiology. 4th edition New York: Wiley-Liss.
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First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP222
Course Name: Microbial Metabolism and Plant Physiology (Elective)

Teaching Scheme: Theory: 4 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course Objectives:

- To study photosynthesis in plants.
- To study about the biosynthesis of carbohydrates and amino acids
- To understand and learn the processes involved in nitrogen fixation.
- Understand the mechanisms of various metabolic and physiological processes in plants and bacteria.

Course Outcomes: On completion of the course students will be able to -

- Understand the biochemistry of biological nitrogen fixation and role of nitrogenase.
- Gain knowledge about biosynthesis of amino acids and nitrogen bases.
- Comment on biosynthesis of carbohydrates in plants and bacteria.
- Acquire basic knowledge about growth and development in plants.
- Ability to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store, utilize and invest free energy.
- show the relationship between photosynthesis and respiration in the flow of energy through a system.

Course Contents:

Unit 1	**Nitrogen Metabolism**	**No of Lectures**
	1. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation. 2. ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation. 3. Biosynthesis of five families of amino acids and histidine. 4. Biosynthesis of purine and pyrimidine bases.	15
Unit 2	**Biosynthesis of carbohydrates in plants and bacteria**	
	1. Calvin cycle and its regulation. 2. Transport of solute across chloroplast membrane. 3. Synthesis of starch and sucrose. 4. Photorespiration, C4 and CAM pathways. 5. Synthesis of cellulose and peptidoglycan. 6. Integration of carbohydrate metabolism in plant cell.	15
Unit 3	**Lipid Biosynthesis**	
	1. Synthesis of storage lipids: Fatty acids and triacylglycerols.	15

	2. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols. 3. Lipids as signal molecules such as phosphatidylinositol, eicosanoids, Vitamins, A, D, K, and E, Dolichols.	
Unit 4	**Plant Physiology**	
	1. Photosynthesis - Light-harvesting complexes, mechanisms of electron transport, photoprotective mechanisms, CO_2 fixation-C3, C4 and CAM pathway. 2. Respiration and photorespiration – Citric acid cycle, plant mitochondrial electron transport and ATP synthesis, alternate oxidase, photorespiratory pathway. 3. Plant hormones – Biosynthesis, storage, breakdown, and transport, physiological effects, and mechanisms of action. 4. Sensory photobiology - Structure, function, and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks. 5. Plant-Microbes Interactions: Plant growth-promoting rhizobacteria	15

References

Unit 1: Nitrogen Metabolism

- White D. (2000). Physiology and Biochemistry of Prokaryotes. 2nd edition. Oxford University Press, New York.
- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Moat, A. G., Foster, J. W., & Spector, M. P. (2002). Microbial physiology.4th Edition New York: Wiley-Liss.

Unit 2: Biosynthesis of carbohydrates in plants and bacteria

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. (2015). Biochemistry. 8th edition,New York: W.H. Freeman.
- Garrett, R. H., and Grisham,C. M. (2004). Biochemistry. 3rd edition. Brooks/Cole, Publishing Company, California

Unit 3: Lipid Biochemistry

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. (2015). Biochemistry. 8th edition,New York: W.H. Freeman
- Garrett, R. H., and Grisham,C. M. (2004). Biochemistry. 3rd Edition Brooks/Cole, Publishing Company, California

Unit 4: Plant Physiology

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 6th edition, Mac Millan Worth Pub. Co. New Delhi
- Madigan M.T.,Martinko J.M., Stahl D.A., Clark D.P (2012). Brock Biology of Microorganisms, 13thedition, Benjamin Cummings, San Francisco.
- Taiz L., Zeiger E, Møller I.M., and Murphy A.(2015), Plant Physiology and Development, 6th edition Sunderland, Massachusetts: Sinauer Associates, Inc., Publishers
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Progressive Education Society's
Modern College of Arts, Science and Commerce (Autonomous)
Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP213
Course Name: Practical course I - Based on Industrial Wastewater Treatment and Quantitative Biology

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- To learn basic techniques required for analysis of wastewater and wastewater treatment efficiency.

Course outcomes: On completion of the course, student will be able to -

- Understand the principles of techniques used in the calculation of pollution load of wastewater, hand-on these methods, and interpretation of results.
- Develop the capacity to comment about the quality of water.
- Students will understand the use of different statistical test such as ANOVA, t-test, etc.
- Students will know the scientific writing.

Course Contents:

I	**Wastewater treatment**	**No. of practicals**
	Estimation of pollution load of a water sample and its interpretation using the following parameters: 1. BOD:COD ratio 2. TS 3. TSS	3
	Simulated waste decomposition using aerobic microorganisms and analysis for the following parameters: 1. Sludge volume index (SVI), 2. Mixed liquor suspended solids (MLSS), 3. Mixed liquor volatile suspended solids (MLVSS), 4. F/M ratio.	4
	Demonstration of the analysis of water sample for: 1. SOx content 2. NOx content 3. Chloride content	3
	Biosorption of dyes using biomass and study of factors affecting biosorption (any two or more factors such as temperature, pH, biomass concentration, incubation time)	2
II	**Data representation and statistical analysis of data**	
	Using data sheets, and sorting data with different parameters	1
	Plotting graphs – bar charts, line graphs, pie charts, scatter plots, error bars, semi-log graphs, regression analysis	2

	Saving graphs/ figures in different formats of image, embedding graphs in PowerPoint presentations, enhancing image quality using GIMP or other software	1
	Statistical analysis of data using following tests of significance in MS Excel (stating hypothesis, level of significance, decision rule, interpretation using p-value and acceptance or rejection of null hypothesis): 1. Students t-test: independent and paired t-test 2. F test 3. ANOVA (one way and two way) 4. Chi-square test of goodness of fit and independence	4
*Any 15 practicals from the above list can be conducted.		

References:

Unit I – Wastewater Treatment

- Environmental Impact Assessment. APH Publishing, R. R. Barthwal, (2002) Environmental Impact Assessment, New Age International.
- John Glasson, Riki Therivel, Andrew Chadwick. Routledge. (2012). Introduction to Environmental Impact Assessment. 4th Edition.
- APHA (2005). Standard Methods for the Examination of Water &Wastewater. 21st Edition. APHA.AWWA.WEF

Unit II - Data representation and statistical analysis of data

- Boslaugh S. (2012). Statistics in a Nutshell. Germany: O'Reilly Media Incorporated.
- Conner N. and MacDonald M. (2013). Office 2013: The Missing Manual. United States: O'Reilly Media.
- McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. Pearson Education.
- Salkind N. J. (2016). Statistics for People Who (Think They) Hate Statistics: Using Microsoft Excel2016. United States: SAGE Publications
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Progressive Education Society's
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Shivajinagar, Pune – 5

First Year of M.Sc. Microbiology
(2023 Course under NEP 2020)
Course Code: 23ScMicP214
Course Name: Practical course II - Based on Enzymology & Metabolism

Teaching Scheme: Practical: 8 Hours/Week **Credit: 04**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Course objectives:

- Explore methods to isolate and characterise bacteria that degrade various compounds.
- Explore methods to isolate PGPR.
- Understand enzyme purification techniques.
- Understand protocols to isolate chloroplast and estimate chlorophyll content in a plant.
- Study enzyme kinetics.

Course outcomes:

- Isolate and characterize starch, and pesticide degrading bacteria and study their degradative potential.
- Isolate PGPR for production of IAA and quantify the IAA produced.
- Isolate chloroplast and estimate chlorophyll content.
- Purify enzymes through various techniques and study their kinetic parameters.
- Determine molecular weight of enzymes by using PAGE.

Course Contents:

I	**Metabolism**	**No. of practical**
	Isolation and characterization of starch degrading bacteria and determination of its starch hydrolyzing potential by calculating its Hydrolyzing Capacity (HC) ratio and amylase activity.	3
	Isolation and characterization of pesticide degrading bacteria and determination of its degradative ability.	3
	Isolation and characterization of facultative anaerobic bacteria.	2
	Isolation of chloroplast	1
	Chlorophyll estimation	1
	Isolation of plant growth promoting rhizobacteria (PGPR) that produces IAA and its quantification.	1
II	**Enzymology**	
	Obtaining crude extract of amylase and its partial purification by fractional ammonium sulphate precipitation followed by dialysis. (*Brief discussion on purification by solvent precipitation.)	3
	Purification of amylase by gel permeation chromatography by preparing suitable column.	2
	Construction of amylase enzyme purification chart	1
	Determination of molecular weight of purified amylase enzyme by Native PAGE and SDS PAGE.	2
	Determination of Km and Vmax values of amylase enzyme.	2
*Any 15 practicals from the above list can be conducted.		

References:

Unit I – Metabolism

- Nelson D. L. and Cox M. M. (2005). Lehninger's Principles of Biochemistry, 4thedition, W. H. Freeman & Co. New York.
- Moat Albert G. and Foster John W. (1988). Microbial Physiology 2nd Edition John Wiley and Sons New York.
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- David T. Plummer (1993) An Introduction to Practical Biochemistry, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi
- Gang S., Sharma, S., Saraf M., Buck M. and Schumacher J. (2019). Analysis of Indole-3-acetic Acid (IAA) Production in Klebsiella by LC-MS/MS and the Salkowski Method. Bioprotocol 9(9): e3230. DOI: 10.21769/BioProtoc.3230.
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- Pratima Gupta, Kalpana Samant, Avinash Sahu, "Isolation of Cellulose-Degrading Bacteria and Determination of Their Cellulolytic Potential", International Journal of Microbiology, vol. 2012, Article ID 578925, 5 pages, 2012. https://doi.org/10.1155/2012/578925.

Unit II – Enzymology

- David T. Plummer (1993) An Introduction to Practical Biochemistry, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi
- Miquet J. G., González L., Sotelo A. I. and González Lebrero R. M. (2019). A laboratory work to introduce biochemistry undergraduate students to basic enzyme kinetics-alkaline phosphatase as a model. Biochem Mol Biol Educ. 47(1):93-99. doi: 10.1002/bmb.21195.
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