Deccan Education Society's

Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum

for 3 years B.Sc./ 4 years B.Sc. (Honours)

Programme as per guidelines of

NEP-2020

for

S. Y. B. Sc. (Microbiology)

With effect from Academic Year

2024- 25

Program Outcomes (POs) for B.Sc. Microbiology	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of an graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioral skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes (PSOs) Upon completion of this programme the student will be able to
PSO1	Academic competence: (i) Understand fundamental concepts, principles and processes underlying the field of Microbiology, its different subfields and its linkage with related disciplinary areas/subjects. (ii) Demonstrate an understanding of a wide range of Microbiological techniques (e.g., basic microscopy, sterilization and disinfection methods, cultivation of microorganisms, isolation techniques, characterization of pathogens, blood grouping, microbiological assays of antibiotics and vitamins, enzyme kinetics, chromatography, electrophoresis, immunological assays.
PSO2	Personal and Professional Competence: (i) Carry out laboratory-orientated numerical calculations and be capable in data visualization and interpretation. (ii) Analyse biochemical data (e.g., in enzyme kinetics, biochemical analysis of serum components, sterility of pharmaceutical products). (iii) Formulate ideas, write scientific reports, demonstrate effective presentation and communication skills.
PSO3	Research Competence: (i) Apply microbiological methodology in order to conduct research and demonstrate appropriate skill to seek solutions to problems that emerge in various fields of Microbiology and interdisciplinary fields. (ii) Integrate informatics and statistical skills to explore and authenticate biological data for experimental and research purposes. (iii) Exhibit awareness of ethical issues in research with emphasis on academic and research ethics, scientific misconduct, intellectual property rights and issues of plagiarism.
PSO4	Entrepreneurial and Social competence: (i) Employ skills in specific areas related to Microbiology such as industrial production, technology development, clinical, health, agriculture and ensure multilevel commitment to health and human welfare.

Deccan Education Society's
Fergusson College (Autonomous), Pune
Department of Microbiology

Second Year Undergraduate Curriculum
as per NEP 2020 Course Structure

Semester	Paper	Paper Code	Paper Title	Credits
III	Major	MIC- 200	Practical III	2
		MIC- 201	Microbial Genetics and Microbial Metabolism	4
	Minor	MIC- 211	Introduction to Medical Microbiology	2
		MIC- 212	Practicals in Medical Microbiology	2
	OE	MIC- 220	Microorganisms in our Environment	2
	VSC	MIC- 230	Clinical Biochemistry	2
	SEC	MIC- 240	Fermented Foods	2
	CEP	MIC- 245	Community Engagement Program	2
IV	Major	MIC- 250	Practical IV	2
		MIC- 251	Environmental Microbiology and Industrial Microbiology	4
	Minor	MIC- 261	Methods in Environmental Microbiology	2
		MIC- 262	Practicals in Environmental Microbiology	2
	OE	MIC- 270	Commercial Microbial Products	2
	VSC	MIC- 280	Biofertilizers	2
	SEC	MIC- 290	Soil and Agricultural Microbiology	2
	FP	MIC- 295	Field Project	2

OE – Open Elective, SEC- Skill Enhancement Component, VSC- Vocational Skill Course

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	3 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

S. Y. B. Sc. Semester 3		
MIC - 200	**Practical III (Major- Practical)**	**Credits: 02 Hours: 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Tell the protocols for performing the different experiments	1
CO2	Perform the different methods for inducing mutations in bacteria Classify the different natural samples into different classes of biomolecules	2
CO3	Perform the different ways of isolation of mutants Solve problems based on UV survival curve	3
CO4	Identify the biomolecules present in different food items	4
CO5	Plan experiments to test for the presence of mutants in a bacterial population.	5
CO6	Collaborate with classmates to design protocols for biochemical characterization of bacterial isolates	6

Unit No	Title of Unit and Contents	No of hours
I	**1. Biochemical characterization of bacteria:** (*E. coli, Pseudomonas aeruginosa*, *Bacillus subtilis*, *Staphylococcus aureus*) a. Sugar utilization test b. Sugar fermentation test c. Enzyme detection tests– Amylase, Gelatinase, Catalase, Oxidase d. Oxidative-fermentative test **2. Diagnostic biochemical tests:** IMViC test	15
II	**1.Induced mutations and Isolation of Mutants** a. Induction of mutations by using physical mutagen (e.g. UV rays) b. Isolation of mutants by any suitable method such as replica plate technique c. Demonstration of UV survival curve **2. Qualitative tests for:** a. Carbohydrates b. Proteins	15

Learning Resources:

1. Aneja K.R. (2014) Laboratory Manual of Microbiology and Biotechnology. Second Edition. Scientific International Pvt. Ltd.
2. Cappuccino, J. G., & Sherman, N. (2014). Microbiology: A Laboratory Manual (10th ed.). Pearson education inc.

S. Y. B. Sc. Semester 3		
MIC - 201	**Microbial Genetics and Microbial Metabolism (Major- Theory)**	**Credits: 04 Hours: 60**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Describe the processes involved in central dogma of life and molecular events in evolution of life on earth. Define the terminologies used in microbial metabolism. Identify the different biomolecules based on their structures and define the role of the biomolecules in different life forms	1
CO2	Illustrate, differentiate and contrast between the structures of DNA and also discuss the DNA replication process. Discuss the evolutionary steps in the evolution of life on earth. Summarize the mechanisms underlying the enzyme-catalyzed reactions and compare and contrast between the structures of different biomolecules	2
CO3	Infer the experiments that led to the discovery of DNA, RNA as genetic material and apply the concepts in understanding the basics of genetics. Complete the reactions of the pathways by which micro-organisms utilize the different substrates available to them and relate the role of a wide variety of enzymes in metabolism	3
CO4	Connect the events hypothesized to occur during evolution of life. Explain the mechanism of gene expression in bacteria. Diagrammatically illustrate the different metabolic pathways occurring in microorganisms. Compare between the different biomolecules.	4
CO5	Compare different types of mutations and appraise the methods of isolation of spontaneous or induced mutants from bacterial population. Review fluctuation test, different types of mutagenic agents and their action on functioning of a cell. Determine the interconnectivity between the different metabolic pathways	5
CO6	Develop concepts about evolution of cell, bacterial genetics and different types of plasmid DNA. Write in detail about the process of generation of energy and the models of catalysis of enzymatic reactions	6

Unit No	Title of Unit and Contents	No of hours
I	**1. Understanding Molecules of Heredity** a. RNA world and shift to DNA world with time b. Evidence for nucleic acid as genetic material in bacteria -	15

	i. Discovery of transforming material (hereditary material): Griffith's experiment. ii. Avery and MacLeod experiment c. Evidence for nucleic acid as genetic material in viruses - i. Gierer and Schramm / Fraenkel-Conrat & Singer experiment (TMV virus) ii. Hershey& Chase experiment (T2 phage) **2. Prokaryotic genome organization** a. Bacterial nucleoid structure, Concept of gene b. Basic structure of B form of DNA c. Comparative account of different forms of DNA **3. Prokaryotic DNA replication** a. J. Cairn's experiment b. Messelson and Stahl's experiment (semiconservative) c. Various models of DNA replication: Θ (theta) mode of replication, rolling circle model d. Mechanism of DNA replication: enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase **4. Concepts of Gene expression** a. Properties of genetic code b. Transcription c. Translation	
II	**Mutations** **1. Spontaneous mutations** a. Occurrence and Mechanisms b. Fluctuation test **2. Mechanisms of induced mutations** **a. Types of mutations:** Base pair substitution (transitions, transversions), frame shift mutations (Insertions and deletions), nonsense, missense, silent, null, leaky & non leaky, conditional lethal mutants (temperature sensitive, amber) **b. Chemical mutagens:** Base analogues (2-amino purine, 5-bromo uracil), HNO_2, alkylating agents (ethyl methyl sulphonate), Intercalating agents (EtBr, acridine orange) **c. Physical mutagens:** UV rays, X rays	15

	d. Biological mutagens: (bacteriophages, transposons) **3. Isolation of Mutants:** Replica plate technique **4. Reversion mutations** a. True reversion b. Suppression (intragenic and intergenic)	
III	**Biomolecules:** **1. Carbohydrates** a. Structure and types b. biological role: storage polysaccharides – starch, structural polysaccharides – cellulose **2. Proteins** a. Amino acids – general formula and concept of zwitterions b. Primary structures of proteins c. Secondary structure of proteins - peptide unit and its salient features, alpha helix and beta pleated sheets and their occurrence in proteins d. Tertiary and quaternary structure of proteins (fibrous and globular proteins) e. Proteins as enzymes i. Nature of active site ii. Structure of active site iii. common amino acids at the active site f. Models of catalysis: i. Lock and key model ii. Induced fit hypothesis iii. Transition state hypothesis **3. Lipids** a. Difference between oils and fats b. Definitions and major classes of storage and structural lipids c. Structure and biological role of fatty acids, essential fatty acids, structure, function and properties of triacylglycerols	15
IV	**Utilization of nutrients:** **1. Definitions:** Metabolism, catabolism, anabolism, respiration, fermentation **2. Metabolic pathways:** a. Glycolysis b. Hexose monophosphate pathway c. Entner- Duodoroff pathway	15

	d. Glyoxylate bypass e. Krebs Cycle (with emphasis on Amphibolism) f. Homofermentative pathway g. Heterofermentative pathway h. Alcohol fermentation **3. Generation of energy:** a. High energy compounds electron transport chain b. Oxidative phosphorylation and substrate level phosphorylation c. Chemiosmotic hypothesis of ATP formation	

Learning resources:

1. Benjamin Lewin (1994) Genes I. Oxford University Press
2. Russel Peter. Essential Genetics. 2nd Edn, Blackwell Science Pub.
3. Watson J.D. (1987) Molecular Biology of the Gene, 4th Ed. The Benjamin Cummings Publishing Company Inc.
4. Nelson D. L. & Cox M. M. (2005). Lehninger's Principles of Biochemistry, 4th Edition, W. H. Freeman & Co. NY.
5. Trevor Palmer and Philip Bonner (2007). Enzymes- Biochemistry, Biotechnology, Clinical Chemistry, 2nd Edition, Woodhead Publishing.

S. Y. B. Sc. Semester 3		
MIC - 211	**Introduction to Medical Microbiology (Minor- Theory)**	**Credits: 02 Hours : 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	List the microorganisms associated with human system and methods of their identification. Describe determinants of bacterial pathogenicity.	1
CO2	Explain the importance of normal flora, opportunistic infections and bacterial pathogenesis	2
CO3	Illustrate schematically steps in bacterial pathogenicity. Outline the importance of probiotics and prebiotics	3
CO4	Compare and contrast normal flora associated with different human systems. Explain mechanisms of bacterial resistance to human defense mechanisms	4
CO5	Review different types of toxins and their roles in bacterial pathogenesis	5
CO6	Design experiments for isolation of microorganisms from clinical samples	6

Unit No	Title of Unit and Contents	No of hours
I	**Concept of normal flora organisms in humans** **1. Normal flora and pathogens (bacteria and viruses) associated with:** a. Gastrointestinal tract b. Skin c. Genitourinary system d. Eyes and conjunctiva e. Respiratory system **2. Significance of normal flora:** a. Role in disease prevention b. Opportunistic pathogens **3. Methods of isolation and identification of bacteria:** a. Biochemical identification of bacteria b. Analytical Profile Index (API) c. Molecular methods of identification of bacteria- 16srRNA gene	15

	sequencing **4. Importance of probiotics and prebiotics**	
II	**Determinants of pathogenicity in bacteria:** 1. Reservoir of infection, adhesion, colonization, invasion 2. Toxigenesis: Different types of toxins 3. Evasion mechanisms of pathogenic organisms 4. Mechanisms of bacterial resistance to host cellular and humoral defenses 5. Pathogenicity Islands and its role in bacterial virulence with suitable examples of pathogens	15

Learning resources:

1. Foundations in Microbiology, Seventh Edition, Talaro. Mcgraw-Hill International Edition
2. Tortora, G.J., Funke, B.R., Case, C.L, 2016. Microbiology: An introduction. 12th Edition, Benjamin Pub. Co. NY
3. Bergey's manual of determinative bacteriology; Bergey, D. H., Holt, John G., 9th ed, Philadelphia : Lippincott Williams & Wilkins
4. Ananthnarayan, R. and C.E, Jayaram Panikar, 2020. Ananthnarayan and Panikar's Textbook of Microbiology, 10th edition, Universities Press.
5. Indira T. Kudva, Nancy A. Cornick, Paul J. Plummer, Qijing Zhang, Tracy L. Nicholson, John P. Bannantine, Bryan H. Bellair 2016. Virulence mechanisms of bacterial pathogens. 5th edition. ISBN: 978-1-555-81927-9.

S. Y. B. Sc. Semester 3		
MIC - 212	**Practicals in Medical Microbiology (Minor- Practical)**	**Credits: 02 Hours : 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Write differences in the growth characteristics of pathogens on different media	1
CO2	Examine the sensitivity of pathogenic organisms to various antimicrobials	2
CO3	Explain the use of Bergey's manual of determinative bacteriology in microbial taxonomy	3
CO4	Classify human pathogens into different groups based on morphological and biochemical tests	4
CO5	Determine the microbial pathogens present in a clinical sample.	5
CO6	Construct a key for identification of bacterial pathogens from a clinical sample.	6

Unit No	Title of Unit and Contents	No of hours
I	**Growth of microorganisms on special media:** a. Salmonella Shigella agar b. Mac Conkeys agar c. Blood agar d. Mannitol Salt agar e. Cetrimide agar	15
II	**1. Isolation and biochemical characterization of pathogens from clinical samples using Bergey's manual of Determinative Bacteriology** a. Isolation of pathogens from stool sample b. Biochemical characterization of pathogens from stool sample c. Isolation of pathogens from urine sample d. Biochemical characterization of pathogens from urine sample 2. Antibiotic susceptibility testing	15

Learning resources:

1. Cruckshank R and J.P. Duguid (1980) Medical Microbiology Volume II, 12th Edition. The Practice of Medical Microbiology, Chruchill Livingstone Edinburgh, London and New York

2. Dubey, R.C. and Maheshwari, D. K. (2002). Practical Microbiology. S Chand and Company Pvt Ltd.

3. Mukherjee K.L. Medical Laboratory Technology – A practical Manual for routine diagnostic tests – Volume I to Volume III. Tata Mac Graw Hill Company.

S. Y. B. Sc. Semester 3		
MIC - 220	**Microorganisms in our Environment (Open Elective)**	**Credits: 02 Hours : 30**
Course Outcome (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Name commonly found organisms in air, water and soil. Define various terms commonly used in air, water and soil microbiology.	1
CO2	Explain recycling and reuse of wastewater and solid waste. Give examples of infections that spread through air and water.	2
CO3	Demonstrate the presence of microorganisms in air using air sampling. Outline the treatment processes used to treat raw water and wastewater.	3
CO4	Compare the treatment processes used to treat different types of wastewater. Explain in brief the bacteriological standards of potable water	4
CO5	Determine the role of microorganisms in soil. Compare various methods of air sanitation.	5
CO6	Write various types of interactions between microorganisms present in soil.	6

Unit No	Title of Unit and Contents	No of hours
I	**1. Air Microbiology** a. Air as a transport medium for microorganisms and air flora b. Droplets, droplet nuclei, and aerosols c. Air borne infections –Viral, bacterial and fungal d. Air sampling using settling plate method e. Air sanitation: Physical and chemical methods **2. Soil Microbiology** a. Rhizosphere microflora and its role in the rhizosphere b. Role of microorganisms in composting and bioremediation c. Interactions of soil microflora with example – Symbiosis and Competition d. Concept of Biofertilizers	15

II	**Water Microbiology** **1. Drinking water** a. Water treatment method for drinking water b. Water borne infections c. Sources of contamination of drinking water d. Detection of fecal contamination of drinking water using indicator bacteria – coliforms **2. Sewage and Waste Water Microbiology** a. Concept of Physico - chemical parameters and Biological parameters of wastewater b. Various types of wastewater treatment processes c. Recycling and reuse of effluent d. Disposal of solid waste – Landfill, composting and biomethane	15

Learning resources:

1. Andrew D Eaton; American Public Health Association.; American Water Works Association.; Water Environment Federation. (2005). Standard methods for the examination of water and wastewater 21st Edition.

2. Prescott, Lancing M., John, P. Harley and Donald, A. Klein (2006). Microbiology, 6th Edition, McGraw Hill Higher Education

3. Michael J Pelczar, JR. E.C.S. Chan, Noel R. Krieg. (1993) Microbiology, 5thEdition,TataMacGraw Hill Press
4. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGrawHill Publishing Co.

S. Y. B. Sc. Semester 3		
MIC - 230	**Clinical Biochemistry** **(Vocational Skill Course)**	**Credits: 02** **Hours : 30**
Course Outcome (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Describe the parameters that show an alteration in association with lifestyle disorders	1
CO2	Categorize the various biochemical tests that need to be performed in various clinical conditions	2
CO3	Illustrate the data obtained from biochemical analyses of samples such as whole blood, serum, urine etc. with clinical symptoms and possible pathologies	3
CO4	Calculate the severity of the tissue damage or lifestyle disorder based on data generated through clinical biochemistry	4
CO5	Compare the efficiency, cost and use of routine laboratory procedures for isolation of bacteria, fungal and viral pathogens with rapid tests.	5
CO6	Specify the use of rapid detection tests under conditions of emergency and unavailability of laboratory resources.	6

Unit No	Title of Unit and Contents	No of hours
I	**Clinical Biochemistry I** **1.** Diabetes Mellitus a. BSL(Fasting and PP) b. GTT c. Hb A1C determination **2.** Kidney function tests a. Estimation of serum total protein & albumin b. Estimation of serum urea & calculation of BUN c. Estimation of uric acid d. Estimation of serum creatinine e. Estimation of blood cystatin C	15

II	**Clinical Biochemistry II** **1.** Liver function tests a. Bilirubin b. SGPT c. SGOT d. Alkaline phosphatase **2.** Lipid profile a. Triglycerides b. HDL c. LDL d. Cholesterol **3.** Ions a. Magnesium b. Calcium c. Sodium d. Phosphorous e. Chloride	15

Learning resources:

1. Chakraborty, P., 2003. A textbook of Microbiology, 2nd Edition New Central Book Agency, India.
2. R.S. Satoskar, S.D. Bhandarkar, 2007.Pharmacology and pharmacotherapeutics, Popular Prakashan, 20th edition.
3. Kanai L. Mukherjee, 2006. Medical laboratory technology.
4. Practical Clinical Biochemistry, Harold Varley4th Edition CBS Publishers and Distributors Pvt. Ltd. New Delhi.
5. Textbook of Biochemistry with clinical correlations Thomas Devlin (Editor); John Wiley and Sons.
6. Biochemistry by U. Satyanarayana and U. Chakrapani 5th Edition; Elsevier Publications.
7. Clinical Biochemistry by Nanda Maheshwari 2nd edition Jaypee Brothers Publications.
8. Medical Physiology by John E. Hall and Michel E. Hall 3rd South Asia Edition, Elsevier Publications.

S. Y. B. Sc. Semester 3		
MIC - 290	**Fermented Foods** **(Skill Enhancement Course)**	**Credits: 02** **Hours: 30**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define and explain basic principles of fermentation	1
CO2	Describe different types of microorganisms used for preparation of fermented food	2
CO3	Demonstrate the role of microorganisms in fermenting various types of foods	3
CO4	Compare the benefits of fermented foods with non- fermented foods.	4
CO5	Evaluate the impact of current trends on the production and consumption of fermented products.	5
CO6	Prepare different fermented foods	6

Unit No	Title of Unit and Contents	No of hours
I	**Introduction to Fermented foods** 1. Definition and basic principles of fermentation, fermented foods. 2. Types of microorganisms involved in fermented foods, Significance of fermentation. 3. Importance of Starter cultures, Role of Lactic Acid Bacteria (LAB) in preservation of food. 4. Current trends in fermented food products	15
II	**Fermented foods with respect to microorganisms involved, outline of the fermentation process and health benefits** 1. Dairy products a. Cheese b. Yogurts c. curd d. buttermilk e. lassi 2. Vegetables products a. Sauerkraut b. Tempeh 3. Fruit products a. Wine b. Cider	15

	c. Beer d. Kombucha 4. Meat products a. Sucuk b. Salami 5. Grains and legumes products a. Idli b. Dosa c. Natto d. Miso 6. Bakery products: Bread 7. Condiments and Sauces a. Fish sauce b. Soy sauce	

Learning resources:

1. Steinkraus K H, (1996). Handbook of Indigenous *Fermented Foods*. Marcel Decker Inc, New York. Anon, (1995), Food for Consumers, Food and Agriculture Organisation
2. Steinkraus, K.H. (1997) Classification of Fermented Foods: Worldwide Review of Household Fermentation Techniques. Food Control, 8, 311-317.
3. Predominant Lactic Acid Bacteria Involved in the Traditional Fermentation of *Fufu* and *Ogi*, Two Nigerian Fermented Food Products Food and nutrition sciences vol 11A.
4. Fermentation: Food Products, Encyclopedia of Agriculture and Food Systems Elsevier publications 2014.
5. Fermented Foods: Definitions and Characteristics, Impact on the Gut Microbiota and Effects on Gastrointestinal Health and Disease. Nutrients 2019 Aug 11(8).

S. Y. B. Sc. Semester 4		
MIC - 250	**Practical IV (Major- Practical)**	**Credits: 02 Hours : 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Describe the process for spore staining and demonstrate the capsule presence.	1
CO2	Discuss the functioning and design of waste-water treatment plant	2
CO3	Demonstrate air sampling techniques and evaluate different sampling parameters.	3
CO4	Classify the organisms capable of producing antibacterial substances and polysaccharides	4
CO5	Measure different diversity indices and interpret the data in terms of probability.	5
CO6	Perform different water potability tests and compare them	6

Unit No	Title of Unit and Contents	No of hours
I	**1. Air Microbiology** a. Demonstration of the working of an air sampler b. Determination of the diversity of air flora and calculation of Simpson's index **2. Water Microbiology** a. Bacteriological tests of potability of water i. MPN, Confirmed and Completed test. ii. Membrane filter technique (Demonstration) 2. Determination of B.O.D. of water sample 3. Determination of total solids and total suspended solids in sewage water **Compulsory visit to waste water treatment plant/ water purification plant**	15
II	**Industrial microbiology** 1. Isolation and checking characters of bacteria producing antibacterial substance from soil by crowded plate technique 2. Giant colony inhibition spectrum	15

	3. Screening of organic acid producing bacteria from soil 4. Isolation and checking characters of exopolysaccharide – producing bacteria from soil 5. Demonstration of presence of capsule and spores in bacteria	

Learning Resources:

1. Andrew D Eaton; American Public Health Association; American Water Works Association.; Water Environment Federation. (2005). Standard methods for the examination of water and wastewater 21st Edition.

2. Casida LE. (1984) Industrial Microbiology. Wiley Easterbs, New Delhi

3. Aneja K.R. (2014) Laboratory Manual of Microbiology and Biotechnology. Second Edition. Scientific International Pvt. Ltd.

S. Y. B. Sc. Semester 4		
MIC - 251	**Environmental Microbiology and Industrial Microbiology (Major- Theory)**	**Credits: 04 Hours: 60**
Course Outcome (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define the primary, secondary pollutants of air. List the airborne, waterborne diseases. Outline the steps involved in the purification of raw water. Recall basics concepts of industrial microbiology including constituents of fermentation media and different types of industrial fermenters.	1
CO2	Compare and contrast between the different methods of secondary treatment of wastewater. Explain the different methods used for sampling and sanitation of air. Compare between different types of industrial fermentations. Explain the process control and monitoring of fermentation parameters.	2
CO3	Calculate the values of different parameters such as BOD, COD, MPN, etc. based on given values. Examine the characteristics of industrial microorganisms and different strain improvement methods.	3
CO4	Relate the industrial processes to environmental pollution. Explain the importance of sterilization in fermentation processes and different sterilization methods.	4
CO5	Evaluate the quality of different water samples based on the values given for different parameters. Justify the use of media for specific fermentation processes.	5
CO6	Propose eco-friendly ways and means for disposal of wastewater. Plan different screening methods for isolating desired microorganism from environment. Devise inoculum development steps in industrial fermentations.	6

Unit No	Title of Unit and Contents	No of hours
I	**Air Microbiology** 1. Air flora a. Transient nature of air flora b. Droplet, droplet nuclei, and aerosols c. Transmission of air-borne pathogens 2. Principles of air sampling for microbial load	10

	a. Impaction on solids b. Impingement in liquid c. Sedimentation 3. Air sanitation a. Physical methods b. Chemical methods	
II	**Water Microbiology** 1. Types of water Natural and processed- surface, ground, stored, distilled, mineral and de-mineralized water 2. Steps in the purification of raw water 3. Bacteriological standards of potable water Maharashtra pollution control board (MPCB), Central pollution control board (CPCB), Bureau of Indian standards (BIS) World health Organization (WHO) 4. Indicators of faecal pollution a. *Escherichia coli* b. *Bifidobacterium* c. *Streptococcus faecalis* d. Bacteriophages e. *Clostridium perfringens* 5. Water borne Infections 6. Bacteriological analysis of water for potability a. Multiple tube fermentation test b. Confirmed test c. Completed test d. Eijkman test f. Membrane filter technique **Sewage and Waste Water Microbiology** 1. Analysis of waste water a. Physico- chemical parameters: pH, temperature, total solids, suspended solids, Chemical Oxygen Demand (C.O.D.) b. Biological parameters: B.O.D., Toxicity (Fish bioassay)	20

	2. Industrial water pollutants, their ecological effects and health hazards (Biomagnification and eutrophication) 3. Methods of effluent treatment a. Primary, secondary, tertiary treatment methods b. Recycling and reuse of waste water c. Treatment of sludge – sludge thickening and dewatering and its disposal; biochemical mechanisms of Biomethanation	
III	**Basic industrial microbiology** 1. Strains of industrially important microorganisms: a. Desirable characteristics of industrial strain b. Different methods of strain improvement i. feedback control mechanisms ii. auxotrophic mutants iii. analogue resistant mutants iv. revertants 2. Screening – Principles and methods of primary and secondary screening 3. Master, working and seed culture, development of inoculum 4. Media for industrial fermentations: Constituents of media: Carbon source, nitrogen source, amino acids and vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors and inducers	15
IV	**Fermentation equipment and process control** 1. Types of fermentation – Batch, continuous and dual fermentation 2. Design of a fermenter (typical CSTR Continuous stirred tank Reactor): different parts and their operation. 3. Continuous stirred tank reactors 4. Contamination and sterilization: a. Sources, precautions, and consequences of contamination b. Sterilization of media-batch and continuous sterilization c. Sterilization by filtration: animal cell culture media 5. Process control and monitoring of different fermentation parameters: temperature, pH, foam	15

Learning resources:

1. Andrew D Eaton; American Public Health Association.; American Water Works Association.; Water Environment Federation. (2005). Standard methods for the examination of water and wastewater 21st Edition.

2. Prescott, Lancing M., John, P. Harley and Donald, A. Klein (2006). Microbiology, 6th Edition, McGraw Hill Higher Education

3. Casida LE. (1984) Industrial Microbiology. Wiley Easterbs, New Delhi

4. Ingraham J. L. and Ingraham C.A. (2004) Introduction to Microbiology. 3nd Edition. Thomson Brooks / Cole.

5. Patel A.H. (1985) Industrial Microbiology, Macmillan India Ltd

S. Y. B. Sc. Semester 4		
MIC - 261	**Methods in Environmental Microbiology (Minor- Theory)**	**Credits: 02 Hours : 30**
Course Outcome (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Understand the role of air and water in the transmission of different micro-organisms	1
CO2	Understand the importance of sanitation of air in different indoor environmental settings	2
CO3	Understand the importance of different steps in the purification of raw water	3
CO4	Understand the different methods for treatment of waste water alongwith the ways of disposal of solid waste	4
CO5	Evaluate the quality of different water samples based on the values given for different parameters	5
CO6	Propose eco-friendly ways and means for disposal of wastewater. Plan different screening methods for isolating desired microorganism from environment.	6

Unit No	Title of Unit and Contents	No of hours
I	**Air and Soil Microbiology** 1. Air flora a. Transient nature of air flora b. Droplet, droplet nuclei, and aerosols c.Transmission of air-borne pathogens. 2. Principles of air sampling for determination of microbial load a. Impaction on solids b. Impingement in liquid c. Sedimentation 3. Air sanitation: Physical and chemical methods 4. Rhizosphere microflora and its plant – growth promoting ability a. Siderophore production b. Phosphate solubilization	15

	c. Nitrogen fixation 5. Concept of Biofertilizers 6. Concepts of Bioremediation (*in situ* and *ex situ*), Biodegradation, Biosurfactants. Xenobiotics and their biomagnification.	
II	**Water Microbiology** 1. Types of water Natural and processed- surface, ground, stored, distilled, mineral and de-mineralized water 2. Steps in the purification of raw water 3. Bacteriological standards of potable water Maharashtra pollution control board (MPCB), Central pollution control board (CPCB), Bureau of Indian standards (BIS) World health Organization (WHO) 4. Indicators of faecal pollution a. *Escherichia coli* b. *Bifidobacterium* c. *Streptococcus faecalis* d. Bacteriophages e. *Clostridium perfringens* 5. Water borne Infections 6. Bacteriological analysis of water for potability a. Multiple tube fermentation test b. Confirmed test c. Completed test d. Eijkman test f. Membrane filter technique **Sewage and Waste Water Microbiology** 1. Analysis of waste water a. Physico- chemical parameters: pH, temperature, total solids, suspended solids, Chemical Oxygen Demand (C.O.D.) b. Biological parameters: B.O.D., Toxicity (Fish bioassay) 2. Industrial water pollutants, their ecological effects and health hazards (Biomagnification and eutrophication) 3. Methods of effluent treatment	15

	a. Primary, secondary, tertiary treatment methods b. Recycling and reuse of waste water c. Treatment of sludge – sludge thickening and dewatering and its disposal; biochemical mechanisms of Biomethanation	

Learning resources:

1. Andrew D Eaton; American Public Health Association.; American Water Works Association.; Water Environment Federation. (2005). Standard methods for the examination of water and wastewater 21st Edition.

2. Prescott, Lancing M., John, P. Harley and Donald, A. Klein (2006). Microbiology, 6th Edition, McGraw Hill Higher Education

3. Soil Microbiology (Fourth Edition of Soil Microorganisms and Plant Growth), N. S. Subba Rao, Oxford and IBH Publishing Company Pvt. Limited, 2005 - 407 pages

4. Soil Microbiology, Ecology and Biochemistry, Eldor Paul, Elsevier, 4th Edition

5. Microbes as Biofertilizers and their production technology (2015). Prof. S. G. Borkar. Woodhead Publishing India in Agriculture.

S. Y. B. Sc. Semester 4		
MIC - 262	**Practicals in Environmental Microbiology (Minor- Practical)**	**Credits: 02 Hours : 30**
Course Outcome (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Describe the process for spore staining and demonstrate the capsule presence.	1
CO2	Discuss the functioning and design of waste-water treatment plant	2
CO3	Demonstrate air-sampling techniques and evaluate different sampling parameters.	3
CO4	Classify the organisms capable of producing antibacterial substances and polysaccharides	4
CO5	Measure different diversity indices and interpret the data in terms of probability.	5
CO6	Perform different water potability tests and compare them	6

Unit No	Title of Unit and Contents	No of hours
I	**Air Microbiology** 1. Demonstration of the working of an air sampler 2. Determination of the diversity of air flora and calculation of Simpson's index **Water Microbiology** 1.Bacteriological tests of potability of water a. MPN b. Confirmed test c. Completed test d. Membrane filter technique (Demonstration) 2. Determination of B.O.D. of water sample 3. Determination of total solids and total suspended solids in sewage water 4. Biodegradation of any one xenobiotic compound **Compulsory visit to waste water treatment plant/ water purification plant**	15

II	**Industrial Microbiology** 1. Isolation and checking characters of bacteria producing antibacterial substance from soil by crowded plate technique 2. Giant colony inhibition spectrum 3. Screening of organic acid producing bacteria from soil 4. Isolation and checking characters of exopolysaccharide – producing bacteria from soil 5. Demonstration of presence of capsule and spores in bacteria	15

Learning resources:

1. Andrew D Eaton; American Public Health Association; American Water Works Association; Water Environment Federation. (2005). Standard methods for the examination of water and wastewater 21st Edition.

2. Prescott, Lancing M., John, P. Harley and Donald, A. Klein (2006). Microbiology, 6th Edition, McGraw Hill Higher Education

S. Y. B. Sc. Semester 4		
MIC - 270	**Commercial Microbial Products (Open Elective)**	**Credits: 02 Hours : 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Define and explain the importance of commercial products.	1
CO2	Analyze the historical evolution of commercial microbial products; classify commercial microbial products based on their source.	2
CO3	Assess the market dynamics of commercial microbial products at both national and international levels.	3
CO4	Explore the utilization of microbial products in producing chemicals, enzymes, bioactive molecules, metabolites, alcoholic and non-alcoholic beverages, and dyes in various industrial processes.	4
CO5	Review the significance of microbial products in day- to- day life.	5
CO6	Compile the information about the importance of commercial microbial products.	6

Unit No	Title of Unit and Contents	No of hours
I	**Introduction to Commercial microbial products:** 1. Definition, Importance of commercial microbial products, 2. History of commercial microbial products, 3. Classification of microbial products on the basis of its source (food, non- food, agricultural and veterinary sources) 4. Comparison with plant and animal derived commercial products 5. Market value and demand at national and international market 6. Future trends and challenges in microbial technology	15
II	**Commercial microbial products used in various sectors with respect to: microorganisms involved and its importance** 1. **Food and Healthcare:** Nutraceuticals, jilebi, yoghurt, acidified milk, dhokla, idli, soy sauce 2. **Agriculture:** Nutrients, biofertilizers, biopesticides and biostimulants	15

	3. **Environment:** Bioremediation**,** Biofuels, wastewater treatment and environmental cleanup 4. **Pharmaceutical:** Antimicrobials, Antibiotics, Chemotherapeutic agents and Vaccines 5. **Other Industries:** Chemicals, Enzymes and Bioactive Molecules, metabolites, Alcoholic and non-alcoholic beverages and dyes	

Learning resources:

1. "Commercial Microbial Products: Insights into Their Definition and Importance" by Robert W. Masters et al. (Journal of Industrial Microbiology & Biotechnology, 2019).
2. Madigan, M. T., & Brock, T. D. (2012). *Brock biology of microorganisms* (13th ed.). Pearson Education.
3. Rani A, Saini KC, Bast F, Varjani S, Mehariya S, Bhatia SK, Sharma N, Funk C. A Review on Microbial Products and Their Perspective Application as Antimicrobial Agents. Biomolecules. 2021 Dec 10;11(12):1860. doi: 10.3390/biom11121860. PMID: 34944505; PMCID: PMC8699383.

S. Y. B. Sc. Semester 4		
MIC - 280	**Biofertilizers** **(Vocational Skill Course)**	**Credits: 02** **Hours : 30**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Describe Plant Growth Promoting Rhizobacteria and their roles	1
CO2	Give examples of Nitrogen fixing, phosphate solubilizing, siderophore producing and IAA producing bacteria	2
CO3	Explain the steps in large scale production of biofertilizers	3
CO4	Explain the importance of biofertilizers over chemical fertilizers	4
CO5	Test the efficiency of biofertilizers using pot trials	5
CO6	Formulate a bio fertilizer on a laboratory scale	6

Unit No	Title of Unit and Contents	No of hours
I	**Isolation of Plant Growth Promoting Rhizobacteria (PGPRs) from soil** 1. Advantages of biofertilizers over chemical fertilizers 2. Bacteriological Media used for cultivation of PGPRs 3. Cultivation of PGPRs a. Nitrogen fixing bacteria (symbiotic and non- symbiotic nitrogen fixing bacteria) b. Phosphate solubilizing bacteria c. Siderophore producing bacteria d. Indole Acetic Acid producing bacteria	15
II	**Large scale production of biofertilizers** 1. Use of carriers for bioinoculant - charcoal, lignite, soil 2. Formulation of biofertilizers – liquid and solid 3. Application of biofertilizers 4. Testing the efficiency of biofertilizers: Pot trials of biofertilizers	15

Learning resources:

1. Rangaswami G. (1979). Recent Advances in Biological Nitrogen Fixation. Oxford and IBH. New Delhi
2. Soil Microbiology (Fourth Edition of Soil Microorganisms and Plant Growth), N. S. Subba Rao, Oxford and IBH Publishing Company Pvt. Limited, 2005 - 407 pages
3. Soil Microbiology, Ecology and Biochemistry, Eldor Paul, Elsevier, 4th Edition
4. Microbes as Biofertilizers and their production technology (2015). Prof. S. G. Borkar. Woodhead Publishing India in Agriculture.

S. Y. B. Sc. Semester 4		
MIC - 240	**Soil and Agricultural Microbiology** **(Skill Enhancement Course)**	**Credits: 02** **Hours : 30**
Course Outcome (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Describe the significance of soil microorganisms and biochemical processes. List the pathogens causing plant diseases.	1
CO2	Discuss the biogeochemical cycles in soil, degradation of complex plant polymers, beneficial and harmful microorganisms.	2
CO3	Illustrate soil characteristics with respect to elemental composition. Explain plant diseases and their causative agents.	3
CO4	Explain soil composition and industrially important microorganisms.	4
CO5	Review the biochemical processes in soil and microorganisms associated with plant diseases.	5
CO6	Write the importance of soil microbiology with respect to decomposition of organic matter, complex polysaccharides, GMOs and plant diseases	6

Unit No	Title of Unit and Contents	No of hours
I	**Soil Microbiology** 1. Physical and chemical properties of soil 2. Overview of biogeochemical cycles 3. Organic matter decomposition: aerobic, anaerobic processes, humus formation, biogas production (methanogens) 4. Degradation of complex plant polymers: pathways of degradation of lignin, pectin, cellulose, hemicellulose degradation	15
II	**Agricultural Microbiology** 1. Bacteria, actinomycetes, fungi, algae, protozoa, viruses 2. Industrially important soil microorganisms and their products, Genetically Modified Microorganisms 3. Plant Pathology: a. Classification of diseases based on symptoms (with one example of each disease) b. Canker, powdery mildew, downy mildew, rust, smut, wilt, spots,	15

	mosaic galls and rots c. Epidemiology of plant diseases d. Methods of plant disease control i. Eradication ii. Chemical control iii. Biological control iv. Integrated Pest Management (IPM)	

Learning resources:

1. Soil Microbiology (Fourth Edition of Soil Microorganisms and Plant Growth), N. S. Subba Rao, Oxford and IBH Publishing Company Pvt. Limited, 2005 - 407 pages
2. Soil Microbiology, Ecology and Biochemistry, Eldor Paul, Elsevier, 4th Edition
   Dube H.C. and Bilgrami K.S. (1976). Textbook of Modern Pathology. Vikas Publishing house, New Delhi