

M.Sc. MICROBIOLOGY

(Effective from the academic year 2024 - 2025)

Vision of the Department:

To address the increasing need for skilled scientific manpower by generating highly qualified Microbiologists with an understanding of research ethics involving microorganisms to contribute to application, advancement and impartment of knowledge in the field of Microbiology globally by providing sustainable competitive edge in the present society.

Mission:

To provide a conducive learning environment with a student-centric atmosphere that allows them to achieve academic excellence in all aspects of Microbiology.

Eligibility for admission to M.Sc. Microbiology:

A candidate who has passed the B.Sc. Degree Examination with a score of 50% and above in Microbiology / Industrial Microbiology / Botany / Plant Science / Plant Biology and Plant Biotechnology / Zoology / Applied Animal Science and Animal Biotechnology / Biochemistry / Biotechnology / Bioinformatics / Biology / Life Sciences / of this University or an Examination of any other University accepted by the Syndicate as equivalent thereto shall be eligible for admission to M.Sc. Degree Programme in Microbiology.

Objectives:

- To impart advanced knowledge and technical skills in Microbiology.
- To expose the students to the recent trends in Microbiology and related sciences.
- To provide training in pure and applied scientific research.
- To emphasis in exploratory research in Microbiology and its associative fields.
- To inculcate professional ethics for careers in Microbiology and entrepreneurial ventures.
- To get sensitized to social and environmental realities with a cognizant of scientific responsibilities

Highlights of the Revamped Curriculum:

- Student-centric, meeting the demands of industry & society, incorporating industrial components, hands-on training, skill development modules, industrial project, project with viva-voce, exposure

to entrepreneurial skills, training for competitive examinations, sustaining the quality of the core components and incorporating application-oriented content wherever required.

- The Core subjects include latest developments in the education and scientific front, practical training, catering to the needs of stakeholders with research aptitude.
- The curriculum is designed to strengthen the industry-academia interface and provide more job opportunities for the students.
- The Internship during the third semester will help the students gain valuable work experience, that connects classroom knowledge to real world experience and to narrow down and focus on the career path.
- State-of Art techniques from the streams of multi-disciplinary, cross disciplinary and inter disciplinary nature are incorporated as Elective and Skill enhancement courses, covering conventional topics to the application oriented.
- Human rights course allows individual in being a responsible citizen that remains as a requisite to the possibility of a just society.
- MOOC course is prescribed to reinforce self-learning and to instill the value of life-long learning in students
- Project with viva-voce component in the fourth semester enables the students to apply their conceptual knowledge to practical situations which will help to improve healthcare, nutrition and the environment.

Value additions in the Revamped Curriculum:

| Semester | Newly introduced Components | Outcome / Benefits |
|---|--|---|
| I, II, III, IV | Core Courses in Microbiology | Students from Microbiology Major in Undergraduation get a stronger footing in the subject, while students from Non-Microbiology Majors are initiated with the grass-root founding in mastering the discipline |
| I, II, III, IV | Elective papers - An open choice of topics categorized under Generic and Discipline Centric | <ul style="list-style-type: none"> ● Strengthening the domain knowledge ● Introducing the stakeholders to the state-of art techniques from the streams of multi-disciplinary, cross disciplinary and inter disciplinary nature ● Emerging topics related to industry are introduced to facilitate advanced learning in the respective domains |
| II, III, IV | Skill Enhancement papers/ Professional competency skills (Discipline centric/ Generic / Entrepreneurial) | <ul style="list-style-type: none"> ● Industry ready graduates ● Skilled human resource ● Students are equipped with essential skills to make them employable ● Entrepreneurial skill training will provide an opportunity for independent livelihood generates small scale entrepreneurs ● Discipline centric skill will improve the technical knowhow of solving real life problems |
| Semester III (Vacation activity) | Internship / Industrial Training | <ul style="list-style-type: none"> ● Practical training at the Industry/ Microbiology & Biotechnology research concerns / Hospitals / /Educational institutions, enable the students gain professional experience and become responsible citizens. |

| | | |
|------------------------|--------------------------|--|
| Semester IV | Project with Viva - voce | <ul style="list-style-type: none"> ● Self-learning, critical thinking, problem-solving and research acumen is enhanced ● Application of the concept to real situation is conceived resulting in tangible outcome |
|------------------------|--------------------------|--|

| | |
|---|---|
| Skills acquired from the Courses | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
|---|---|

TANSCHÉ BASED PROGRAMME STRUCTURE FOR M.Sc. MICROBIOLOGY
(For the candidates admitted from the academic year 2024-2025)

| Sem | Part | Category | Paper Code | Title | Hours/ Week | Exam | | Credits | Marks |
|--------------|---------------------------------|---|--|--|----------------|------|-----|-----------|------------|
| | | | | | | Th | Pr | | |
| I | I | Core Course I | PCMBA24 | General Microbiology and Microbial Diversity | 6 | 3 | - | 5 | 40+60 |
| | | Core Course II | PCMBB24 | Immunology, Immunomics and Microbial Genetics | 6 | 3 | - | 5 | 40+60 |
| | | Core Course III | PCMBC24 | Practical - I: General Microbiology, applied immunology and molecular biology techniques | 6 | - | 6+6 | 4 | 40+60 |
| | I | Elective Course I (Discipline Centric) | PEMBA24 | Forensic Science | 5 | 3 | - | 3 | 40+60 |
| | | | PEMBB24 | Health and Hygiene | | | | | |
| | | | PEMBC24 | Microalgal Technology (Among the three choices anyone can be chosen by the student) | | | | | |
| | Elective Course II (Generic) | PEMBD24 | Bioinstrumentation | 5 | 3 | - | 3 | 40+60 | |
| | | PEMBE24 | Herbal Technology and Cosmetic Microbiology | | | | | | |
| | | PEMBF24 | Essentials of Laboratory Management and Biosafety (Among the three choices anyone can be chosen by the student) | | | | | | |
| II | | | | Human Rights | 1 | - | - | - | - |
| | | | | Value Education | 1 | - | - | - | - |
| Total | | | | | 30 | | | 20 | 300 |
| II | I | Core Course IV | PCMBD24 | Medical Bacteriology and Mycology | 6 | 3 | - | 5 | 40+60 |
| | | Core Course V | PCMBE24 | Medical Virology and Parasitology | 6 | 3 | - | 5 | 40+60 |
| | | Core Course VI | PCMBF24 | Practical – II: Medical Microbiology | 6 | - | 6+6 | 4 | 40+60 |
| | I | Elective Course III (Discipline Centric) | PEMBG24 | Epidemiology | 4 | 3 | - | 3 | 40+60 |
| | | | PEMBH24 | Clinical Diagnostic Microbiology | | | | | |
| | | | PEMBI24 | Bioremediation (Among the three choices anyone can be chosen by the student) | | | | | |
| | Elective Course IV (Generic) | PEMBJ24 | Bioinformatics | 4 | 3 | - | 3 | 40+60 | |
| | | PEMBK24 | Nanobiotechnology | | | | | | |
| | | PEMBL24 | Clinical Research and Clinical Trials (Among the three choices anyone can be chosen by the student) | | | | | | |
| | II | Skill Enhancement Course [SEC I] | PSMB124 | SEC: Vermitechnology | 2 | - | - | 2 | 100 |
| | | | PNHRA24 | Human Rights | 1 | 2 | - | 2 | 40+60 |
| | | | | Value Education | 1 | - | - | - | - |
| POMB24 | | | Online Course | - | - | - | 1 | - | |
| Total | | | | | 30 | | | 25 | 700 |

| Sem | Part | Category | Paper Code | Title | Hours/ Week | Exam | | Credits | Marks |
|--------------------|--------------------|-----------------------------------|---|--|----------------|------|-----|--------------|-------------|
| | | | | | | Th | Pr | | |
| III | I | Core Course VII | PCMBG24 | Soil and Environmental Microbiology | 6 | 3 | - | 5 | 40+60 |
| | | Core Course VIII | PCMBH24 | Molecular Biology and Recombinant DNA Technology | 6 | 3 | - | 5 | 40+60 |
| | | Core Course IX | PCMBI24 | Practical III: Applied Microbiology | 6 | - | 6+6 | 5 | 40+60 |
| | | Core Course X [Industry Module] | PCMBJ24 | Fermentation Technology and Pharmaceutical Microbiology | 6 | 3 | - | 4 | 40+60 |
| | I | Elective Course V | PEMBM24 | Biosafety, Bioethics and IPR | 3 | 3 | - | 3 | 40+60 |
| | | | PEMBN24 | Entrepreneurship And Management in Microbial Technology | | | | | |
| | | | PEMBO24 | Water Conservation and Water Treatment (Among the three choices anyone can be chosen by the student) | | | | | |
| | II | Skill Enhancement Course [SEC II] | PSMB224 | SEC: Organic Farming and Biofertilizer Technology | 2 | - | - | 2 | 100 |
| | | | PIMB24 | Internship | - | - | - | 2 | |
| | | | | Value Education | 1 | - | - | - | - |
| Total | | | | | 30 | | | 26 | 600 |
| IV | | Core Course X | PCMBK24 | Food and Dairy Microbiology | 6 | 3 | - | 5 | 40+60 |
| | | Core Course XII | PCMBL24 | Research Methodology & Biostatistics | 6 | 3 | - | 5 | 40+60 |
| | | Project | PCMBP24 | Project with Viva Voce | 10 | - | - | 7 | 40+60 |
| | Elective Course VI | PEMBP24 | Bioenergy | 4 | 3 | - | 3 | 40+60 | |
| | | PEMBQ24 | Marine Microbiology | | | | | | |
| | | PEMBR24 | Life Science for Competitive Examinations (Among the three choices anyone can be chosen by the student) | | | | | | |
| | | Professional Competency Skill | PPMB24 | Microbial Quality Control and Testing | 3 | - | - | 2 | 100 |
| | | | | Value Education | 1 | - | - | - | - |
| PXTEN24 | | | Extension activity (30 Hours) | - | - | - | 1 | - | |
| Total | | | | | 30 | | | 23 | 500 |
| Grand Total | | | | | 120 | | | 94+2* | 2300 |

- Any one course of the following to be completed during III semester (15 hours teaching and 15 hours activities):
 - i) Teaching and Research Aptitude
 - ii) Artificial Intelligence Tools
 - iii) Entrepreneur Skill
 - iv) Photography

| Methods of Evaluation | | | | | | |
|------------------------------|--|---------------------------------|----------------------|--------------------|------------------|----|
| S. No. | Category | Assessment Tool | Maximum Marks | Exam Theory | Weightage | |
| 1 | Core Courses/Generic & Discipline Specific Electives | I Continuous Assessment (ICA) | 50 | 1 ½ h | 35 | 40 |
| | | II Continuous Assessment (IICA) | 50 | 1 ½ h | | |
| | | Innovative Component (IC) | 5 | - | 5 | |
| | | End Semester Examination | 100 | 3 h | | 60 |
| 2 | Professional Competency | I Continuous Assessment (ICA) | 30 | 1 h | 35 | 40 |
| | | II Continuous Assessment (IICA) | 30 | 1 h | | |
| | | Innovative Component (IC) | 5 | - | 5 | |
| | | End Semester Examination | 60 | 2 h | | 60 |
| 3 | HR | Continuous Assessment (IICA) | 25 | 1 h | | 40 |
| | | Innovative Component (IC) | 25 | - | | |
| | | End Semester Examination | 60 | 2 h | | 60 |

Activity-based Assessment for Skill Enhancement Courses:

Activity 1 for Unit I: (Nature of Activity) – 20 marks

Activity 2 for Unit II: (Nature of Activity) – 20 marks

Activity 3 for Unit III: (Nature of Activity) – 20 marks

Activity 4 for Unit IV: (Nature of Activity) – 20 marks

Activity 5 for Unit V: (Nature of Activity) – 20 marks

Nature of Activity – Field visit/Industrial visit/Project (individual or group)/Exhibits/Model making/Hands on training/Lab practice/Product making/Extempore/Block and Tackle/Debate/Report writing/Case study/Interpretation of data or results/Transcription/Quiz (LMS)/Problem solving/ Designing/Role play/Start-up proposal/Research proposal/Poster presentation/Oral presentation (live or video recorded)/Survey (Field or Online)/Group discussion/Problem solving/Problem formulation/Interviews/Concept mapping/Mind mapping /Promoting public awareness etc.

Record of Assessment will be maintained by the course instructors and verified by the Head of the department.

| Cognitive Levels of Assessment | |
|--|---|
| Recall (K1) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand/ Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, short summary or Overview |
| Application (K3) | Suggest idea/concept with examples, suggest formulae, Solve problems, Observe, Explain |
| Analyze (K4) | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

PROGRAMME OUTCOMES (PO)

Programme Outcomes (PO)

On completion of the PG Programme, students will be able to:

PO1: Attain an in-depth knowledge in the respective domains augmented through self-learning.

PO2: Assimilate and apply principles and concepts towards skill development and employability.

PO3: Apply critical and scientific approaches to address problems and find solutions.

PO4: Develop research skills through multi/inter/trans-disciplinary perspectives.

PO5: Integrate issues of social relevance in the field of study.

PO6: Persist in life-long learning for personal and societal progress.

Programme Specific Outcomes (PSO):

On completion of the PG Programme in Microbiology, students will be able to;

PSO1: Attain an in-depth knowledge in the anatomy and physiology of a repertoire of microorganisms with its beneficial and harmful associations.

PSO2: Demonstrate practical skills in the use of tools, technologies and methods common to microbiology, and apply the scientific method and hypothesis testing in the design and execution of experiments.

PSO3: Develop ability to independently carry out a complete scientific work process with research ethics, including the understanding of theoretical background, hypothesis generation, collection and analysis of

data, and interpretation and presentation of results.

PSO4: Acquaint a broader knowledge in the concepts of Taxonomy, molecular biology, immunology, food, environment and agricultural microbiology, nanotechnology, forensic science and genetic engineering.

PLO5: Incorporate effective career with marketing, project management, business development or venture capital within the biotech, pharmaceutical, medical technology or related fields.

PSO6: Compete in state/national level competitive exams to pursue higher study with an understanding that education is life-long process for personal and societal progress.

| PSO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---------------|------------|------------|------------|------------|------------|------------|
| PSO1 | H | M | M | H | L | M |
| PSO2 | H | H | H | H | L | M |
| PSO3 | H | M | H | H | M | L |
| PSO4 | H | M | M | H | L | H |
| PSO5 | H | H | L | M | M | H |
| PSO6 | H | H | H | H | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|---------|
| Title of the Course | GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY | | | | | | |
| Paper No. | Core Course I | | | | | | |
| Category | Core | Year | I | Credits | 5 | Course Code | PCMBA24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Acquire knowledge on the principles of different types of microscopes and their applications. • Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria. • Exemplify, isolate and cultivate microalgae from diverse environmental sources. • Explain various pure culture techniques and discuss sterilization methods. • Discuss the importance and conservation of microbial diversity. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4 , K5 & K6)</p> <p>History, scope of Microbiology & Microscopy</p> <p>1.1 History and Scope of Microbiology. 1.2 Microscopy – Principles and applications. 1.3 Types of Microscopes - Bright field, Dark-field. 1.4 Phase-contrast, Fluorescence microscope. 1.5 Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. 1.6 Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.</p> | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Cellular components of bacteria, fungi and its growth</p> <p>2.1 Bacterial Structure, properties and biosynthesis of cellular components – Cell wall. 2.2 Actinomycetes - Distribution, morphology, classification, reproduction and economic importance. 2.3 Fungi - Distribution, morphology, classification, reproduction and economic importance. 2.4 Sporulation. 2.5 Growth and nutrition - Nutritional requirements. 2.6 Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.</p> | | | | | | |
| | <p>UNIT III (15 hours) (K1, K2, K3, K4 ,K5 & K6)</p> <p>Algae and its importance</p> <p>3.1 Algae - Distribution, morphology, classification. 3.2 Reproduction and economic importance. 3.3 Isolation of algae from soil and water. 3.4 Media and methods used for culturing algae, Strain selection and large-scale cultivation. 3.5 Life cycle - <i>Chlamydomonas</i>, <i>Volvox Spirogyra</i> (Green algae), <i>Nostoc</i> (Cyanobacteria) 3.6 <i>Ectocarpus</i>, <i>Sargassum</i> (Brown algae), <i>Polysiphonia</i>, <i>Batrachospermum</i> (Red algae).</p> | | | | | | |

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| | <p>UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Basic Techniques in Microbiology</p> <p>4.1 Microbial techniques - Safety guidelines in Microbiology Laboratories.</p> <p>4.2 Sterilization, Disinfection and its validation.</p> <p>4.3 Staining methods – Simple, Differential and Special staining.</p> <p>4.4 Automated Microbial identification systems.</p> <p>4.5 Pure cultures techniques – Cultivation of Anaerobic organisms.</p> <p>4.6 Maintenance and preservation of pure cultures. Culture collection centres - National and International.</p> |
| | <p>UNIT V (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microbial Biodiversity</p> <p>5.1 Biodiversity - Introduction to microbial biodiversity and Conservation of Biodiversity.</p> <p>5.2 Thermophiles - Classification, Thermophilic Archaeobacteria and its applications.</p> <p>5.3 Methanogens - Classification, Habitats, applications.</p> <p>5.4 Alkaliphiles and Acidophiles - Classification, discovery basin, its cell wall and membrane.</p> <p>5.5 Barophiles - Classification and its applications.</p> <p>5.6 Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes, Osmoadaptation / halotolerance - Applications of halophiles.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd. 2. Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York. 3. Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6th Edition). McGraw - Hill company, New York. 4. White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York. 5. Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited. |
| Reference Books | <ol style="list-style-type: none"> 1. Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12th Edition). Pearson, London, United Kingdom. 2. Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3rd Edition). Cambridge University Press, Cambridge. 3. Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elsevier Academic Press, California. 4. Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2nd Edition). Books / Cole Thomson Learning, UK. 5. Madigan M. T., Bender K.S., Buckley D. H. Sattley W. M. and Stahl (2018) Brock Biology of Microorganisms. (15th Edition). Pearson. |

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| Web resources | <ol style="list-style-type: none"> 1. http://sciencenetlinks.com/tools/microbeworld 2. https://www.microbes.info/ 3. https://www.asmscience.org/VisualLibrary 4. https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404 5. https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf |
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| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes. |
| CO2 | Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions. |
| CO3 | Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance. |
| CO4 | Create aseptic conditions by following good laboratory practices. |
| CO5 | Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | M | L | H | L | M |
| CO2 | H | H | L | M | L | H |
| CO3 | H | H | H | H | M | H |
| CO4 | H | M | L | H | L | H |
| CO5 | H | L | M | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | L | M | L | M |
| CO2 | H | H | H | M | M | M |
| CO3 | H | H | L | M | L | M |
| CO4 | H | M | M | H | L | M |
| CO5 | H | M | M | H | L | M |

(HIGH - 3, MODERATE - 2, LOW - 1)

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| Title of the Course | IMMUNOLOGY, IMMUNOMICS AND MICROBIAL GENETICS | | | | | | |
| Paper No. | Core Course II | | | | | | |
| Category | Core | Year | I | Credits | 5 | Course Code | PCMBB24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Discuss immunity, organs and cells involved in immunity. Compare the types of antigens and their properties. • Describe immunoglobulin and its types. Categorize MHC and understand its significance. • Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development. • Acquire knowledge the structure DNA in prokaryotes and eukaryotes • Explain out gene transfer studies in microbes. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Immune System and Immunity</p> <p>1.1 Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin, development, differentiation, lymphocyte subpopulation in humans.</p> <p>1.2 Innate immunity and Acquired immunity – Active and Passive immunity.</p> <p>1.3 Antigens - features associated with antigenicity and immunogenicity.</p> <p>1.4 Basis of antigen specificity.</p> <p>1.5 MHC genes and products, Structure of MHC molecules.</p> <p>1.6 Antigen processing and presentation to T- lymphocytes.</p> | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Immunoglobulins and Complement System</p> <p>2.1 Immunoglobulins. Theories of antibody production.</p> <p>2.2 Class switching and generation of antibody diversity.</p> <p>2.3 Monoclonal and polyclonal antibodies.</p> <p>2.4 Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions.</p> <p>2.5 Antigen recognition – TCR.</p> <p>2.6 Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.</p> | | | | | | |

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| | <p>UNIT III (25 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Hypersensitivity and Diagnostic immunology</p> <p>3.1 Hypersensitivity – Types and mechanisms. Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies.</p> <p>3.2 Genetics of Immunohematology – Genetic basis and significance of ABO and Rh System.</p> <p>3.3 Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis.</p> <p>3.4 Agglutination- Labeled Assay- Immunofluorescence assay, Radio immunoassay, ELISA. Role of cytokines, lymphokines and chemokines.</p> <p>3.5 Introduction to Vaccines and Adjuvants - Types of vaccines.</p> <p>3.6 Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.</p> |
| | <p>UNIT IV (13 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Prokaryotic and Eukaryotic genome</p> <p>4.1 Concept of gene and Gene regulation.</p> <p>4.2 Structure of prokaryotic and eukaryotic genome.</p> <p>4.3 Organization of gene in prokaryotes and eukaryotes.</p> <p>4.4 Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome.</p> <p>4.5 Modifications- methylation, acetylation, phosphorylation.</p> <p>4.6 Gene expression system – Lac and Trp operons</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Gene Transfer Mechanism</p> <p>5.1 Identification of Genetic Material (Griffith, Avery and Hershy and Chase Experiments)</p> <p>5.2 Transformation – Natural competence cells. Regulation and importance of natural transformation.</p> <p>5.3 Transduction- Generalized and Specialized.</p> <p>5.4 Conjugation, types and its uses.</p> <p>5.5 Triparental Mating and its importance.</p> <p>5.6 Transposition, Mechanism and Types of Transposition reactions.</p> |
| <p>Text Books</p> | <ol style="list-style-type: none"> 1. Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5th Edition). Wiley-Blackwell, New York. 2. Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7th Edition). W. H. Freeman and Company, New York. |

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| | <ol style="list-style-type: none"> 3. Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10th Edition). Elsevier. 4. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi. 5. Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8th Edition). Wiley India Pvt. Ltd. |
| Reference Books | <ol style="list-style-type: none"> 1. Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York. 2. Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11th Edition). Wiley-Blackwell. 3. Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4th Edition). Wiley-Blackwell. 4. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press. 5. Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.ncbi.nlm.nih.gov/books/NBK279395/ 2. https://med.stanford.edu/immunol/phd-program/ebook.html 3. https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/ 4. [PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in 5. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity. |
| CO2 | Justify the significance of MHC molecules in immune response and antibody production. |
| CO3 | Design antibodies and evaluate immunological assays in patient samples. |
| CO4 | Analyze genomic DNA of prokaryotes and eukaryotes. |
| CO5 | Summarize gene transfer mechanisms for experimental study. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | L | M | M | H | H |
| CO2 | H | L | H | L | M | H |
| CO3 | H | L | H | L | M | H |
| CO4 | H | L | M | M | H | H |
| CO5 | H | M | M | L | M | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | L | H | M | H | H |
| CO2 | H | L | H | M | M | H |
| CO3 | H | L | H | L | M | H |
| CO4 | H | L | H | M | H | H |
| CO5 | H | M | H | L | M | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | PRACTICAL I: GENERAL MICROBIOLOGY, APPLIED IMMUNOLOGY AND MOLECULAR BIOLOGY TECHNIQUES | | | | | | |
| Paper No. | Core Course III | | | | | | |
| Category | Practical | Year | I | Credits | 4 | Course Code | PCMBC24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | - | - | 6 | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Gain knowledge on the fundamentals, handling and applications of microscopy, sterilization methods. Identify microbes by different staining methods. • Prepare media for bacterial growth. Discuss plating and growth measurement techniques. • Acquire adequate skills to perform blood grouping and serological reactions. • Provide fundamental skills in preparation, separation and purification of immunoglobulin. • Apply the knowledge of molecular biology skills in clinical diagnosis. | | | | | | |
| Course Outline (Experiments) | <ol style="list-style-type: none"> 1. Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Dark field microscopy – Motility. 2. Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration. Quality control check for each method. 3. Staining techniques - Simple staining, Gram's staining, Acid fast staining, Spore and Capsule. 4. Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media. 5. Preparation of Biochemical test media, media to demonstrate enzymatic activities. 6. Microbial Physiology: Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer. Anaerobic culture methods. 7. Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate. Bacterial growth curve. 8. Hematological reactions - Blood Grouping – forward and reverse, Rh Typing Identification of various immune cells by morphology – Leishman staining. Agglutination Reactions- Latex Agglutination reactions- RF, ASO. 9. Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and single radial immunodiffusion (SRID) 10. Immuno-electrophoresis - Rocket immuno electrophoresis and counter current immuno electrophoresis – (Demonstration). 11. Preparation of lymphocytes from peripheral blood by density gradient centrifugation – (Demonstration). 12. Isolation of genomic DNA from E. coli and analysis by agarose gel electrophoresis 13. Estimation of DNA using colorimeter (Diphenylamine reagent). 14. Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) – (Demonstration). 15. UV induced mutation and isolation of mutants by replica plating technique. | | | | | | |

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| | 16. Plasmid DNA isolation from <i>E.coli</i> . 17. RNA isolation from yeast. RNA estimation by Orcinol method. 18. Western blotting – (Demonstration) . |
| Text Books | 1. Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand. 2. Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi. 3. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). Taylor & Francis. 4. Rich R. R., Fleisher T. A., Shearer W. T., Schroeder H, Frew A. J. and Weyand C. M. (2018). Clinical Immunology: Principles and Practice. (5th Edition). Elsevier. 5. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press. |
| Reference Books | 1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. 2. Gupta P. S. (2003). Clinical Immunology. Oxford University Press. 3. Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd. 4. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. 2012. 5. Maloy S. R., Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing Home Pvt Ltd. |
| Web resources | 1. http://textbookofbacteriology.net/ 2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/ 3. https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/ 4. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Apply microscopic techniques and staining methods in the identification and differentiation of microbes. |
| CO2 | Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth. |
| CO3 | Perform and evaluate immunological reactions to aid diagnosis. |
| CO4 | Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques. |
| CO5 | Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | H | L | H |
| CO2 | H | H | M | H | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | H | H | H | L | H |
| CO5 | H | H | H | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | M | M | M | H |
| CO4 | H | H | M | M | M | H |
| CO5 | H | H | L | M | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE I A: FORENSIC SCIENCE | | | | | | |
| Paper No. | Elective Course I | | | | | | |
| Category | Elective (Discipline centric) | Year | I | Credits | 3 | Course Code | PEMBA24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 5 | - | - | | 5 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Understand the Scope, need and learn the tools and techniques in forensic science. • Comprehend organizational setup of a forensic science laboratory. • Identify and Examine body fluids for identification. • Extract DNA from blood samples for investigation. • Recognize medico legal post mortem procedures and their importance. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Forensic Science – History and Introduction</p> <p>1.1 Forensic Science - Definition, history and development of forensic science. 1.2 Scope and need of forensic science in present scenario. 1.3 Branches of forensic science. 1.4 Tools and techniques of forensic science. 1.5 Duties of a forensic scientist. 1.6 Development and scope of Forensic Science in India.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Organization of Forensic Science Laboratories</p> <p>2.1 Forensic science laboratories - Organizational setup of a forensic science laboratory. 2.2 Central and State level laboratories in India. 2.3 Mobile forensic science laboratory and its functions. 2.4 Forensic microbiology - Types and identification of microbial organisms of forensic significance. 2.5 Polygraph Narco analysis. 2.6 Brain electrical oscillation.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Forensic serology</p> <p>3.1 Crime investigation- Biology. 3.2 Forensic characterization of bloodstains. 3.3 Forensic serology – introduction and definition. 3.4 Identification and examination of body fluids - Blood, semen, saliva, sweat and urine.</p> | | | | | | |

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| | <p>3.5 Forensic examination and identification of hair and fibre.</p> <p>3.6 Gel diffusion techniques.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>DNA profiling and fingerprinting</p> <p>4.1 DNA profiling - Introduction, history of DNA typing.</p> <p>4.2 Forensic significance of DNA fingerprinting.</p> <p>4.3 Extraction of DNA from blood samples - Organic and Inorganic extraction methods.</p> <p>4.4 DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity. Professional and ethical issues.</p> <p>4.5 Identification, Techniques and Technologies (Finger Print Technology, Face Recognition, IRIS, Retina Geometry)</p> <p>4.6 Advanced Methods for Forensic DNA Examination.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Forensic toxicology</p> <p>5.1 Forensic toxicology - introduction and definition.</p> <p>5.2 concept of forensic toxicology and its scope.</p> <p>5.3 Introduction to Narcotic drugs, Depressants, stimulants, and Hallucinogens their Active components and method of analysis.</p> <p>5.4 Extraction methods of poisons from viscera, blood and urine.</p> <p>5.5 Medico legal post mortem and their examination.</p> <p>5.6 Poisons - Types of poisons and their mode of action.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Nanda B. B. and Tewari R. K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN 13:9788190113526. 2. James S. H. and Nordby, J. J. (2015) Forensic Science: An Introduction to Scientific and Investigative Techniques. (5th Edition). CRC Press. ISBN-10:9781439853832 / ISBN 13:978-1439853832. 3. Li R. (2015) Forensic Biology. (2nd Edition). CRC Press, New York. ISBN-13:978-1-4398 8972-5. 4. Sharma B.R (2020) Forensic science in criminal investigation and trials. (6th Edition) Universal Press. 5. Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12th Edition). Pearson Press. |

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| Reference Books | <ol style="list-style-type: none"> 1. Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3. 2. Saferstein R. and Hall A. B. (2020). Forensic Science Hand book, Vol. I, (3rd Edition). CRC Press, New York. ISBN-10:1498720196. 3. Lincoln, P.J. and Thomson, J. (1998). (2nd Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3. 4. Val McDermid (2014). Forensics. (2nd Edition). ISBN 9780802125156. 5. Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2nd Edition). CRC Press. |
| Web resources | <ol style="list-style-type: none"> 1. http://clsjournal.ascls.org/content/25/2/114 2. https://www.ncbi.nlm.nih.gov/books/NBK234877/ 3. https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8 4. https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics 5. https://cisac.fsi.stanford.edu/events/microbial_forensics |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Identify the scope and need of forensic science in the present scenario. |
| CO2 | Plan for the organizational setup and functioning of forensic science laboratories. |
| CO3 | Analyze the biological samples found at the crime scene. |
| CO4 | Perform extraction and identification of DNA obtained from body fluids. |
| CO5 | Discuss the concept of forensic toxicology. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | L | H | H | M | H | H |
| CO2 | L | H | H | M | H | H |
| CO3 | L | L | M | M | M | H |
| CO4 | M | H | H | H | M | H |
| CO5 | M | H | H | H | M | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | M | L | H |
| CO2 | H | H | H | M | L | H |
| CO3 | H | L | M | M | L | H |
| CO4 | H | H | H | H | L | H |
| CO5 | H | H | H | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE I B: HEALTH AND HYGIENE | | | | | | |
| Paper No. | Elective Course I | | | | | | |
| Category | Elective (Discipline centric) | Year | I | Credits | 3 | Course Code | PEMBB24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 5 | - | - | | 5 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Acquire knowledge on hygiene and live healthy. • Provide insights on health laws for food safety and hygiene. • Explain health, physical exercises and their importance. • Illustrate mental hygiene and involved in mental hygiene. • Describe the various health and health education programmes by the government. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Introduction to health and hygiene</p> <p>1.1 Introduction to hygiene and healthful live. 1.2 Relation between health, hygiene & sanitation 1.3 Factors affecting health, health habits and practices. 1.4 Recognizing positive & negative practices in the community. 1.5 Scientific principles related to health. 1.6 Relevance & importance of health, hygiene in the contemporary times</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Nutrition and Health</p> <p>2.1 Nutrition and Health – introduction. 2.2 Balanced diet and food surveillance. 2.3 Food Fortification, adulteration and preventive measures. 2.4 Water, Sanitation and Hygiene (WASH): Concept, Meaning, Principles, and Practices 2.5 Health laws for food safety. 2.6 Environmental and housing hygiene. Ventilation and lighting.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Physical Health</p> <p>3.1 Physical health, physical exercises and their importance. 3.2 Walking, jogging, yoga and meditation – for stress relief. 3.3 International control of health, WHO. 3.4 Personal hygiene, Sun bathing, Colon Hygiene. 3.5 Health destroying habits and addictions - Pan, supari, ganja, drinking, smoking, tea and coffee.</p> | | | | | | |

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| | 3.6 Dietary management of disease and disorders. |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Mental Hygiene</p> <p>4.1 Mental hygiene - factors responsible, developmental tasks, basic needs, emotional stability.</p> <p>4.2 Mental hygiene and health in infancy, early childhood, adolescence, adulthood and old age.</p> <p>4.3 Mental health occupational hazards.</p> <p>4.4 Factors influencing stress- causes and remedial measures.</p> <p>4.5 Psychology of adjustment.</p> <p>4.6 Defense mechanisms –Displacement, Repression, Projection, Sublimation and Rationalization.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Health Education</p> <p>5.1 Communicable and non-communicable diseases – an overview.</p> <p>5.2 Factors responsible for spread of a communicable disease</p> <p>5.3</p> <p>5.4 Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes.</p> <p>5.5 Immunization Programmes.</p> <p>5.6 Challenges of implementation of public health in India.</p> <p>5.7 Family planning, Reproductive and Child health programmes (RCH).</p> |
| Text Books | <ol style="list-style-type: none"> 1. Bamji M. S., Krishnaswamy K. and Brahmam G. N. V. (2019). Textbook of Human Nutrition. (4th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 2. Swaminathan (1995) Food& Nutrition (Vol I) (2nd Edition). The Bangalore Printing &Publishing Co Ltd., Bangalore. 3. Lindsay Dingwall.(2010). Personal Hygiene Care Print ISBN:9781405163071 Online ISBN:9781444318708 DOI:10.1002/9781444318708 4. Walter C. C. Pakes (1900). The Science of Hygiene: a Text-book of Laboratory Practice. (London: Methuen and Co.,). |
| Reference Books | <ol style="list-style-type: none"> 1. Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi. 2. Srilakshmi, B. (2010) Food Science, (5th Edition) New Age International Ltd., New Delhi. 3. Park K. (2007) Park’s text book of Preventive and Social Medicine, Banarsidas Bhanot publishers, India. 4. Srilakshmi, B. (2002), Dietetics, New Age Publications, India |

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| Web resources | <ol style="list-style-type: none"> 1. Health and Hygiene - Personal Hygiene, Community Hygiene and Diseases (vedantu.com) 2. Chapter-32.pdf (nios.ac.in) 3. Menstrual Health and Hygiene Guide Student Health and Counseling Services (ucdavis.edu) 4. https://nap.nationalacademies.org/read/11756/chapter/13 5. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=112325 |
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| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Identify factors affecting health and health habits. |
| CO2 | Execute the knowledge of ventilation and lighting. Justify Health laws for food safety and hygiene. |
| CO3 | Follow personal hygiene to avoid diseases and Prevent people from health-destroying habits and addictions. |
| CO4 | Explore Mental hygiene and maintain emotional stability. |
| CO5 | Participate in health education programmes |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | M | M | M | H |
| CO4 | H | H | M | M | M | H |
| CO5 | H | H | L | M | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | L | M | H | L | H |
| CO3 | H | L | M | H | L | H |
| CO4 | H | L | M | H | L | H |
| CO5 | H | M | H | M | M | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE I C: MICROALGAL TECHNOLOGY | | | | | | |
|------------------------------|---|---------|----------|--------------|-------|-------------|---------|
| Paper No. | Elective Course I | | | | | | |
| Category | Elective (Discipline centric) | Year | I | Credits | 3 | Course Code | PEMBC24 |
| Instructional hours per week | | Lecture | Tutorial | Lab Practice | Total | | |
| Objectives of the course | <ul style="list-style-type: none"> • Characterize the different groups of algae. • Describe the cultivation and harvesting of algae. • Identify the commercial applications of various algal products. • Apply microalgae for environmental applications. • Employ microalgae as alternate fuels. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Algae – an introduction</p> <p>1.1 Introduction to Algae - General characteristics. 1.2 Phylogeny of algae. 1.3 Classification of algae. 1.4 Salient features of different groups of algae. 1.5 Distribution - Freshwater, brackish water and marine algae. 1.6 Algal identification methods.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Cultivation of algae</p> <p>2.1 Cultivation of freshwater and marine microalgae. 2.2 Growth media, isolation and enumeration of microalgae. 2.3 Laboratory cultivation and maintenance. 2.4 Outdoor cultivation - Photobioreactors - construction, types and operation. 2.5 Raceway ponds - Heterotrophic and mixotrophic cultivation. 2.6 Harvesting of microalgae biomass.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microalgae as nutraceutical and fertilizer</p> <p>3.1 Microalgae in food and nutraceutical applications- Algal single cell proteins. 3.2 Cultivation of Spirulina. 3.3 Microalgae as aquatic, poultry and cattle feed. 3.4 Microalgal biofertilizers. 3.5 Value-added products from microalgae. Pigments - Production of microalgal carotenoids and their uses. 3.6 Microalgal secondary metabolites - Pharmaceutical and cosmetic applications.</p> | | | | | | |

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| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microalgae in environmental applications</p> <p>4.1 Microalgae in environmental applications - introduction. 4.2 Phycoremediation - Domestic and industrial waste water treatment. 4.3 High-rate algal ponds and surface-immobilized systems. 4.4 Treatment of gaseous wastes by microalgae. 4.5 Algal blooms and its significance. 4.6 Algicides for algal control.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microalgal fuels</p> <p>5.1 Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. 5.2 Lipid-rich algal strains - <i>Botryococcus braunii</i>. 5.3 Drop-in fuels from algae - hydrocarbons and biodiesel. 5.4 Bioethanol, biomethane from algae. 5.5 Biohydrogen and syngas from microalgae biomass. 5.6 Advantages of algal biofuel.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Lee R.E. (2008). Phycology. Cambridge University Press. 2. Sharma O.P. (2011). Algae. Tata McGraw-Hill Education. 3. Shekh A., Schenk P., Sarada R. (2021). Microalgal Biotechnology. Recent Advances, Market Potential and Sustainability. Royal Society of Chemistry. 4. Lele. S.S., Jyothi Kishen Kumar (2008). Algal bio process technology. New Age International P(Ltd) 5. Das., Mihirkumar. (2015) Algal Biotechnology. Daya Publishing House, New Delhi. |
| Reference Books | <ol style="list-style-type: none"> 1. Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier. 2. Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRC Press. 3. Singh B., Baudhdh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer. 4. Das D. (2015). An algal biorefinery: An integrated approach. Springer. 5. Bux F. and Chisti Y. (2016). Algae Biotechnology: Products and Processes. Springer. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.classcentral.com/course/algae-10442 2. https://onlinecourses.nptel.ac.in/noc19_bt16/preview 3. https://freevidelectures.com/course/4678/nptel-industrial-biotechnology/46 4. https://nptel.ac.in/courses/103103207 5. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Acquire knowledge in the field of microalgal technology and their characteristics. |
| CO2 | Identify the methods of algal cultivation and harvesting. |
| CO3 | Recognize and recommend the use of microalgae as food, feed and fodder. |
| CO4 | Promote microalgae in phycoremediation. |
| CO5 | Compare and critically evaluate recent applied research in these microalgal applications. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | M | L | M | M | H |
| CO3 | H | M | L | M | M | H |
| CO4 | H | M | H | H | H | H |
| CO5 | H | L | M | L | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | M | L | M | L | H |
| CO3 | H | M | L | M | L | H |
| CO4 | H | M | H | H | L | H |
| CO5 | H | L | M | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE II A: BIOINSTRUMENTATION | | | | | | |
|------------------------------|--|----------|--------------|---------|-------|-------------|----------------|
| Paper No. | Elective Course II | | | | | | |
| Category | Elective (Generic) | Year | I | Credits | 3 | Course Code | PEMBD24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 5 | - | - | | 5 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Explain the principles and working mechanisms of laboratory instruments. • Discuss chromatography techniques and molecular biology techniques. • Illustrate molecular techniques in biological applications. • Acquire knowledge on spectroscopic techniques. • Demonstrate the use of radio isotopes in various techniques. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Basic Laboratory Instruments</p> <p>1.1 Basic laboratory Instruments. Aerobic and anaerobic incubator. 1.2 Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. 1.3 Centrifugation techniques: Basic principles of centrifugation. 1.4 Standard sedimentation coefficient. 1.5 Measurement of sedimentation co-efficient. 1.6 Applications in determination of molecular weight.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Chromatography</p> <p>2.1 General principles of chromatography. 2.2 Chromatographic Performance parameters 2.3 Types- Thin layer chromatography, Paper Chromatography, Adsorption, ion exchange, Gel filtration, affinity. 2.4 Flash Chromatography and Ultra Performance convergence chromatography. 2.5 Two-dimensional chromatography and stimulated moving bed chromatography (SEC). 2.6 Applications of chromatography.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Electrophoresis</p> <p>3.1 Electrophoresis: General principles. 3.2 Moving boundary electrophoresis - electrophoretic mobility – supportive materials – electro endosmosis. 3.3 Types (horizontal, vertical and two-dimensional electrophoresis) -Principle and applications. 3.4 Paper electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel,</p> | | | | | | |

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| | <p>3.5 SDS – PAGE, Immuno electrophoresis.</p> <p>3.6 Blotting techniques -Southern, northern and western blotting.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Spectroscopy</p> <p>4.1 Spectroscopic techniques: Principle.</p> <p>4.2 Simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation.</p> <p>4.3 Application of UV- visible, Raman, FTIR spectrophotometer.</p> <p>4.4 Spectrofluorimetry, Atomic Absorption Spectrophotometer, Flame spectrophotometer.</p> <p>4.5 NMR, ESR, Emission Flame Photometry and GC-MS.</p> <p>4.6 Detection of molecules in living cells - FISH and GISH.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Radioisotopic techniques</p> <p>5.1 Radioisotopic techniques: Principle.</p> <p>5.2 Applications of tracer techniques in biology.</p> <p>5.3 Radioactive isotopes - radioactive decay.</p> <p>5.4 Detection and measurement of radioactivity.</p> <p>5.5 Geiger- Muller and Scintillation counters.</p> <p>5.6 Auto radiography and its applications- safety aspects.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Sharma B. K. (2014). Instrumental Method of Chemical Analysis. Krishna Prakashan Media (P) Ltd. 2. Chatwal G. R and Anand S. K. (2014.) Instrumental Methods of Chemical Analysis. Himalaya Publishing House. 3. Mitchell G. H. (2017). Gel Electrophoresis: Types, Applications and Research. Nova Science Publishers Inc. 4. Holme D. Peck H. (1998). Analytical Biochemistry. (3rd Edition). Prentice Hall. 5. Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2ndEdition). Wiley Eastrn Ltd., New Delhi. |
| Reference Books | <ol style="list-style-type: none"> 1. Pavia D. L. (2012) Spectroscopy (4th Edition). Cengage. 2. Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14th Edition). W.B.Saunders Co., Philadephia. 3. Miller J. M. (2007). Chromatography: Concepts and Contrasts (2nd Edition) Wiley Blackwell. 4. Gurumani N. (2006). Research Methodology for Biological Sciences. (1st Edition) MJP Publishers. 5. Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1st Edition). MJP Publishers. |

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| Web resources | <ol style="list-style-type: none"> 1. https://norcaloa.com/BMIA 2. http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge-introduction-types-uses-and-other-details-with-diagram/12489 3. https://www.watelectrical.com/biosensors-types-its-working-and-applications. 4. http://www.wikiscales.com/articles/electronic-analytical-balance/ 5. https://study.com/academy/lesson/what-is-chromatography-definition-types-uses. |
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| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP. |
| CO2 | Apply chromatography techniques in the separation of biomolecules. |
| CO3 | Perform electrophoretic techniques. |
| CO4 | Estimate molecules in biological samples by adopting UV spectroscopic techniques. |
| CO5 | Detect and measure radioactivity by radioisotopic techniques. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | L | L | M |
| CO2 | H | H | H | L | L | M |
| CO3 | H | H | H | L | L | M |
| CO4 | H | H | H | L | L | M |
| CO5 | H | H | H | L | L | M |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | L | L | M |
| CO2 | H | H | H | L | L | M |
| CO3 | H | H | H | L | L | M |
| CO4 | H | H | H | L | L | M |
| CO5 | H | H | H | L | L | M |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE II B: HERBAL TECHNOLOGY AND COSMETIC MICROBIOLOGY | | | | | | |
| Paper No. | Elective Course II | | | | | | |
| Category | Elective (Generic) | Year | I | Credits | 3 | Course Code | PEMBE24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 5 | - | - | | 5 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Impart knowledge of Indian Medicinal Plants and their applications in microbiology. • Promote the technical skills involved in preparation of different types of plant extracts. • Explain methods to analyze the antimicrobial activity of medicinal plants. • Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics. • Gain insight into pharmacopeial microbial assays and biosafety. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Herbs and Herbal medicine</p> <p>1.1 Herbs, Herbal medicine – introduction. 1.2 Indian medicinal plants. 1.3 Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. 1.4 Basic principles involved in Ayurvedha. 1.5 Basic principles involved in Sidha and Unani. 1.6 Basic principles involved in Homeopathy.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Collection and authentication of Indian medicinal plants</p> <p>2.1 Collection and authentication of selected Indian medicinal plants. 2.2 Emblica officinalis, withania somnifera, Phyllanthus amarus. 2.3 Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum. 2.4 Azardirchata indica, Terminalia chebula, Allium sativum. 2.5 Preparation of extracts- Hot and cold methods. 2.6 Preparation of stock solutions.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Antimicrobial sensitivity testing</p> <p>3.1 Antimicrobial activity of selected Indian medicinal Plants- an introduction. 3.2 Significance of antimicrobial sensitivity testing. 3.3 In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. 3.4 MIC - Macro dilution techniques.</p> | | | | | | |

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| | <p>3.5 MIC - Micro dilution techniques.</p> <p>3.6 Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Cosmetic Microbiology</p> <p>4.1 History of Cosmetic Microbiology.</p> <p>4.2 Need for cosmetic microbiology.</p> <p>4.3 Scope of cosmetic microbiology.</p> <p>4.4 Role of microbes in cosmetic preparation.</p> <p>4.5 Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi.</p> <p>4.6 Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Cosmetics testing and preservation</p> <p>5.1 Cosmetic microbiology test methods.</p> <p>5.2 Antimicrobial preservative efficacy.</p> <p>5.3 Microbial content testing and biological toxicological testing.</p> <p>5.4 Validation methods - bioburden and Pharmacopeial microbial assays.</p> <p>5.5 Preservatives of cosmetics.</p> <p>5.6 Global regulatory and toxicological aspect of cosmetic preservatives.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977. 2. Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911. 3. Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344. 4. Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3rd Edition). CRC Press. ISBN:9780429113697. 5. Brannan D. K. (1997). Cosmetic microbiology: A Practical Handbook. CRC Press. ISBN-10:0849337135. |
| Reference Books | <ol style="list-style-type: none"> 1. Indian Herbal Pharmacopoeia (2002). Vol. I & II Indian Drug Manufacturers Association, Mumbai. 2. British Herbal Pharmacopoeia. (1990). Vol. I. British Herbal Medicine Association. ISBN: 0903032090. 3. Verpoorte R. and Mukherjee, P. K. (2010). GMP for Botanicals: Regulatory and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2nd edition). Saujanya Books, Delhi. ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856. 4. Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233. |

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| | 5. Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press. Totowa, NJ, USA. ISBN-10:1617371904. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts 2. https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl 3. https://pubmed.ncbi.nlm.nih.gov/17004305/ 4. https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics 5. https://pubmed.ncbi.nlm.nih.gov/15156038/ |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Identify the applications of Indian medicinal plants in treating diseases. |
| CO2 | Identify and authenticate herbal plants. |
| CO3 | Evaluate the antimicrobial activity of medicinal plants. |
| CO4 | Describe the role of microorganisms and their metabolites in the preparation of cosmetics. |
| CO5 | Validate procedures and biosafety measures in the mass production of cosmetics. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | M | H | L | L | H |
| CO2 | H | M | H | L | L | H |
| CO3 | H | M | H | L | L | H |
| CO4 | H | M | H | L | L | H |
| CO5 | H | M | H | L | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | M | H | L | L | H |
| CO2 | H | M | H | L | L | H |
| CO3 | H | M | H | L | L | H |
| CO4 | H | M | H | L | L | H |
| CO5 | H | M | H | L | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|---|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE II C: ESSENTIALS OF LABORATORY MANAGEMENT AND BIOSAFETY | | | | | | |
| Paper No. | Elective Course II | | | | | | |
| Category | Elective (Generic) | Year | I | Credits | 3 | Course Code | PEMBF24 |
| | | Semester | I | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 5 | - | - | | 5 | | |
| Objectives of the course | <ul style="list-style-type: none"> • To utilize containment principles to ensure biosafety. • To enrich the student role and responsibilities of laboratory hazards and their control. • To know the importance of first aid technique for various common lab accidents. • To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory. • To discuss the biosafety regulations and guidelines and implementation of safety programs. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Laboratory and Laboratory hazards</p> <p>1.1 Introduction to the laboratory and laboratory hazards. 1.2 General laboratory facilities. 1.3 Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. 1.4 General laboratory rules. 1.5 Good laboratory practice (GLP). 1.6 Laboratory plan.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Chemical and Physical Hazards</p> <p>2.1 Common hazards in laboratory: Chemical hazards. 2.2 Safe handling of chemicals and gases, hazard labels and symbols. 2.3 Material safety datasheet (MSDS), Chemical handling - Fume hood, Storage of chemicals. 2.4 Chemical Waste Disposal Guideline. 2.5 Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. 2.6 Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.</p> | | | | | | |

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| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Prevention of Laboratory accidents</p> <p>3.1 Prevention and First aid for laboratory accidents.</p> <p>3.2 Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators).</p> <p>3.3 Disposal/Removal of PPE.</p> <p>3.4 Emergency equipment safety - Showers/ Eye Washes.</p> <p>3.5 Laboratory security and emergency response.</p> <p>3.6 First aid for - Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biohazard and biosafety</p> <p>4.1 Biosafety - Historical background. Blood borne pathogens (BBP) and laboratory - acquired infections.</p> <p>4.2 Introduction to biological safety cabinets. Primary containment for biohazards.</p> <p>4.3 Biosafety levels of specific microorganisms. Recommended biosafety.</p> <p>4.4 Levels for infectious agents and infected animals. Risk groups with examples - Risk assessment. Case studies - Safe working, hand hygiene.</p> <p>4.5 Laboratory instruments, packing, sending, transport, import and export of biological agents.</p> <p>4.6 Hygiene, disinfection, decontamination, sterilization.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biosafety regulations and guidelines.</p> <p>5.1 Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration.</p> <p>5.2 Recombinant DNA advisory committee (RDAC).</p> <p>5.3 Institutional biosafety committee (IBSC).</p> <p>5.4 Review committee on genetic manipulation (RCGM).</p> <p>5.5 Genetic engineering approval committee (GEAC).</p> <p>5.6 Implementation of biosafety guidelines.</p> |
| <p>Text Books</p> | <ol style="list-style-type: none"> 1. Sateesh M. K. (2013). Bioethics and Biosafety, IK International Pvt Ltd. ISBN: 8190675702. 2. Muthuraj M. and Usharani B. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN 10: 1645878856 3. Biosafety in Microbiological and Biomedical Laboratories - U.S. Health Department and Human Services. (2016). (5th Edition). Lulu.com. 4. Kanai. L. Mukherjee. (2018). Medical Laboratory Technology (4th Edition). CBS Publishers. 5. Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers. |

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| Reference Books | <ol style="list-style-type: none"> 1. World Health Organization, Biosafety programme management. (2010). (4th Edition). WHO Publications. 2. Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1st Edition). 3. Dayuan X. (2015). Biosafety and Regulation for Genetically Modified Organisms, Alpha Science International Ltd, ISBN-10 : 1842657917 4. Ochei J. Kolhatkar (2000). A. (Medical Laboratory Science – Theory and Practice. ISBN; 13:978-0074632239. 5. Lynne S. Garcia. (2013). Clinical Laboratory Management (2nd Edition). ASM Press. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.cdc.gov/labs/pdf/CDCBiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf 2. https://ucanapplym.s3.ap-south-1.amazonaws.com/RGU/notifications/E_learning/Online_study/PG-SEM-IV-Biosafety%20regulation.pdf 3. https://consteril.com/biosafety-levels-difference/ 4. https://www.cdc.gov/labs/pdf/CDCBiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf 5. https://www.who.int/publications/i/item/9789240011311 |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Employ skills on laboratory safety and avoid laboratory accidents. |
| CO2 | Prevent laboratory hazards by practicing safety strategies. |
| CO3 | Practice various first aid procedures during common laboratory accidents. |
| CO4 | Ensure biosafety strategies in laboratory. |
| CO5 | Recognize the importance of biosafety guidelines. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | M | M | H |
| CO2 | H | H | M | L | L | H |
| CO3 | H | M | L | H | M | H |
| CO4 | H | M | L | H | M | H |
| CO5 | H | H | M | M | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | L | H | H |
| CO2 | H | H | H | M | L | H |
| CO3 | H | H | H | L | M | H |
| CO4 | H | M | H | L | M | H |
| CO5 | H | H | H | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | MEDICAL BACTERIOLOGY AND MYCOLOGY | | | | | | |
| Paper No. | Core Course IV | | | | | | |
| Category | Core | Year | I | Credits | 5 | Course Code | PCMBD24 |
| | | Semester | II | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens. • Explain morphology, characteristics and pathogenesis of bacteria. • Discuss various factors leading to pathogenesis of bacteria. • Acquire knowledge on antifungal agents and their importance. • Describe various diagnostic methods available for fungal disease diagnosis. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Clinical and diagnostic Microbiology</p> <p>1.1 Classification of medically important bacteria. 1.2 Normal flora of human body. 1.3 Collection, transport, storage of clinical specimens. 1.4 Processing of clinical specimens. 1.5 Microbiological examination of clinical specimens. 1.6 Antimicrobial susceptibility testing.</p> | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important bacteria - I</p> <p>2.1 Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of Staphylococci. 2.2 Streptococci, Pneumococci and Neisseriae. 2.3 Bacillus. 2.4 Clostridium. 2.5 Corynebacteria. 2.6 Mycobacteria.</p> | | | | | | |
| | <p>UNIT III (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important bacteria – II</p> <p>3.1 Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members. 3.2 Pseudomonas and Vibrio. 3.3 Yersinia, Mycoplasma and Helicobacter. 3.4 Rickettsiae, Chlamydiae, Bordetella, Francisella.,</p> | | | | | | |

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| | <p>3.5 Spirochaetes- Leptospira, Treponema and Borrelia.</p> <p>3.6 Nosocomial, zoonotic and opportunistic infections -prevention and control.</p> |
| | <p>UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important fungi - I</p> <p>4.1 Morphology, taxonomy and classification of fungi.</p> <p>4.2 Detection and recovery of fungi from clinical specimens.</p> <p>4.3 Dermatophytes and agents of superficial mycoses- Trichophyton, Epidermophyton & Microsporum.</p> <p>4.4 Yeasts of medical importance – Candida, Cryptococcus.</p> <p>4.5 Mycotoxins.</p> <p>4.6 Antifungal agents.</p> |
| | <p>UNIT V (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important fungi - II</p> <p>5.1 Dimorphic fungi causing Systemic mycoses- an introduction.</p> <p>5.2 Histoplasma and Coccidioides.</p> <p>5.3 Sporothrix and Blastomyces.</p> <p>5.4 Fungi causing Eumycotic Mycetoma.</p> <p>5.5 Opportunistic fungi- Fungi causing secondary infections in immunocompromised patients.</p> <p>5.6 Immunodiagnostic methods in mycology.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (2017). Orient Longman, Hyderabad. 2. Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London. 3. Finegold, S. M. (2000) Diagnostic Microbiology, (10th Edition). C.V. Mosby Company, St. Louis. 4. Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4th Edition). Wiley Publishers. 5. Chander J. (2018). Textbook of Medical Mycology. (4th Edition). Jaypee brothers Medical Publishers. |
| Reference Books | <ol style="list-style-type: none"> 1. Salle A. J. (2007). Fundamental Principles of Bacteriology. (4th Edition). Tata McGraw-Hill Publications. 2. Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). Mackie & McCartney Practical Medical Microbiology. 14thedn, Churchill Livingston. 3. Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22ndedn.Cambridge University Press. 4. Topley and Wilson's. (1998). Principles of Bacteriology.9th edn. Edward Arnold, London. |

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| | 5. Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th edn. Elsevier, Mosby Saunders. |
| Web resources | <ol style="list-style-type: none"> 1. http://textbookofbacteriology.net/nd 2. https://microbiologysociety.org/members-outreach-resources/links.html 3. https://www.pathselective.com/micro-resources 4. http://mycology.cornell.edu/fteach.html 5. https://www.adelaide.edu.au/mycology/ |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Collect, transport and process of various kinds of clinical specimens. |
| CO2 | Analyze various bacteria based on morphology and pathogenesis. |
| CO3 | Discuss various treatment methods for bacterial disease. |
| CO4 | Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents. |
| CO5 | Apply various immunodiagnostic method to detect fungal infections. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | M | M | M | H | H |
| CO2 | H | H | H | H | H | H |
| CO3 | H | H | H | M | M | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | M | L | L | M | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | M | M | M | M | H |
| CO2 | H | H | H | H | M | H |
| CO3 | H | H | H | M | M | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | M | L | L | M | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | MEDICAL VIROLOGY AND PARASITOLOGY | | | | | | |
|------------------------------|---|----------|--------------|---------|-------|-------------|----------------|
| Paper No. | Core Course V | | | | | | |
| Category | Core | Year | I | Credits | 5 | Course Code | PCMBE24 |
| | Semester | II | | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Describe the replication strategy and cultivation methods of viruses. • Acquire knowledge about oncogenic virus and human viral infections. • Develop diagnostic skills, in the identification of virus infections. • Impart knowledge about parasitic infections. • Develop diagnostic skills, in the identification of parasitic infections. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>General Properties of Virus</p> <p>1.1 General properties of viruses - Structure and Classification. 1.2 Viroids, prions, satellite RNAs and virusoids. 1.3 Cultivation of viruses - embryonated eggs, experimental animals and cell cultures. 1.4 Purification and Assay of viruses – Physical methods (Electron Microscopy). 1.5 Chemical methods (Protein and Nucleic acids studies.) 1.6 Infectivity Assays (Plaque and end point).</p> | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important Viruses</p> <p>2.1 Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox, Herpes, Adeno, Papova and Hepadna. 2.2 RNA Viruses- Picorna, Orthomyxo, Paramyxo. 2.3 Rhabdo and Rota virus. 2.4 HIV and other Hepatitis viruses. 2.5 Arbo – Dengue virus, Ebola virus. 2.6 Emerging and reemerging viral infections</p> | | | | | | |
| | <p>UNIT III (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bacterial viruses</p> <p>3.1 Bacterial viruses - ΦX 174, M13, MU. 3.2 T4, lambda, Pi. 3.3 Structural organization, life cycle and phage production. Lysogenic cycle. 3.4 Diagnosis of viral infections.</p> | | | | | | |

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| | <p>3.5 Antiviral agents.</p> <p>3.6 Viral vaccines.</p> |
| | <p>UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important Protozoans and blood parasites</p> <p>4.1 Introduction to Medical Parasitology – Classification, host parasite relationships.</p> <p>4.2 Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – Entamoeba and Giardia.</p> <p>4.3 Leishmania.</p> <p>4.4 Trypanasoma.</p> <p>4.5 Plasmodium.</p> <p>4.6 Trichomonas and Balantidium.</p> |
| | <p>UNIT V (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Medically important Helminths</p> <p>5.1 Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes – Taenia Solium and T. Saginata.</p> <p>5.2 Trematodes – Fasciola Hepatica, Fasciolopsis buski.</p> <p>5.3 Paragonimus and Schistosomes.</p> <p>5.4 Nematodes - Ascaris, Ankylostoma, Trichuris,</p> <p>5.5 Enterobius, Strongyloides and Wuchereria.</p> <p>5.6 Other parasites causing infections in immune compromised hosts and AIDS.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Kanunga R. (2017). Ananthanarayanan and Panicker’s Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd. 2. Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S. Chand & Co. 3. Rajan S. (2007). Medical Microbiology. MJP publisher. 4. Paniker J. (2006). Text Book of Parasitology. Jay Pee Brothers, New Delhi. 5. Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5th Edition). CBS Publishers & Distributors Pvt. Ltd. New Delhi. |
| Reference Books | <ol style="list-style-type: none"> 1. Carter J. (2001). Virology: Principles and Applications (1st Edition). Wiley Publications. 2. Willey J., Sandman K. and Wood D. Prescott’s Microbiology. (11th Edition). McGraw Hill Book. 3. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A. 4. Finegold S.M. (2000). Diagnostic Microbiology. (10th Edition). C.V. Mosby Company, St. Louis. |

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| Web resources | <ol style="list-style-type: none"> 1. https://en.wikipedia.org/wiki/Virology 2. https://academic.oup.com/femsre/article/30/3/321/546048 3. https://www.sciencedirect.com/science/article/pii/S0042682215000859 4. https://nptel.ac.in/courses/102/103/102103039/ 5. https://www.healthline.com/health/viral-diseases#contagiousness |
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| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay. |
| CO2 | Investigate the symptoms of viral infections and presumptively identify the viral disease. |
| CO3 | Diagnose various viral diseases by different methods (serological, conventional and molecular) |
| CO4 | Educate public about the spread, control and prevention of parasitic diseases. |
| CO5 | Identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|--------|------|------|------|------|------|------|
| CO1 | H | M | M | M | H | H |
| CO2 | H | H | H | H | H | H |
| CO3 | H | H | H | M | M | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | M | L | L | M | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-------|-----|-----|-----|-----|-----|-----|
| CO1 | H | M | M | M | M | H |
| CO2 | H | H | H | H | M | H |
| CO3 | H | H | H | M | M | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | M | L | L | M | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | PRACTICAL II: MEDICAL MICROBIOLOGY | | | | | | |
|------------------------------|--|----------|--------------|---------|-------|-------------|----------------|
| Paper No. | Core Course VI | | | | | | |
| Category | Practical | Year | I | Credits | 4 | Course Code | PCMBF24 |
| | Semester | II | | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | - | - | 6 | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Develop skills in the diagnosis of bacterial infections. • Perform antimicrobial sensitivity tests. • Impart knowledge on fungal infections and its diagnosis. • Characterize bacterial viruses • Diagnose parasitic infection. | | | | | | |
| Course Outline (Experiments) | <ol style="list-style-type: none"> 1. Staining of clinical specimens - Wet mount, Differential and Special staining methods. 2. Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media – 3. Biochemical identification tests. 4. Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method. Minimum inhibitory concentration (MIC) test. Minimum Bactericidal concentration (MBC) test. 5. Identification and Classification of common fungi. Examination of different fungi by Lactophenol cotton blue staining. 6. Examination of different fungi by KOH mount – skin and nail scrapping. 7. Cultivation of fungi and their identification - Mucor, Rhizopus, Aspergillus, Penicillium. 8. Examination of parasites in clinical specimens - Ova/cysts in faeces. 9. Concentration methods – Flootation methods - simple Saturated salt solution method – Zinc sulphate methods 10. Sedimentation methods- Formal ether method. 11. Blood smear examination for malarial parasites. Leishman's stain. 12. Isolation and characterization of bacteriophage from natural sources by phage titration. 13. Cultivation of viruses – Egg Inoculation methods. 14. Diagnosis of Viral Infections – ELISA (Demonstration). 15. Spotters of viral inclusions and CPE-stained smears. 16. Identification of common arthropods of medical importance - spotters of Anopheles, Aedes, Ticks and mites. | | | | | | |
| Text Books | <ol style="list-style-type: none"> 1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2nd Edition. Publisher-Taylor and Francis. 2. Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press. 3. Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House. 4. Cappuccino, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi. | | | | | | |

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| | 5. Morag C. and Timbury M.C. (1994). Medical Virology. 4th edn. Blackwell Scientific Publishers. |
| Reference Books | <ol style="list-style-type: none"> 1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. 2. Chart H. (2018). Practical Laboratory Bacteriology. CRC Press. 3. Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd. 4. Cheesbrough M. (2006). District Laboratory Practice in Tropical countries - Part 22nd Edition. Cambridge University Press. 5. Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th Edition. Elsevier, Mosby Saunders |
| Web resources | <ol style="list-style-type: none"> 1. http://textbookofbacteriology.net/ 2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173454/ 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768729/ 4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/ 5. https://www.intechopen.com/books/current-issues-in-molecular-virology-viral-genetics-and-biotechnological-applications/vaccines-and-antiviral-agents |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Collection of different clinical samples, transport, culture and examination. |
| CO2 | Identify medically important bacteria by staining and biochemical tests. |
| CO3 | Examine fungus and parasites from the clinical samples |
| CO4 | Perform antibiotic sensitivity tests and compare with the standard tests. |
| CO5 | Promote diagnostic skills; interpret laboratory tests in the diagnosis of infectious diseases. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | H | L | H |
| CO2 | H | H | M | H | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | H | H | H | L | H |
| CO5 | H | H | H | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | M | M | M | H |
| CO4 | H | H | M | M | M | H |
| CO5 | H | H | L | M | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE III A: EPIDEMIOLOGY | | | | | | |
|------------------------------|---|----------|--------------|---------|-------|-------------|---------|
| Paper No. | Elective Course III | | | | | | |
| Category | Elective (Discipline centric) | Year | I | Credits | 3 | Course Code | PEMBG24 |
| | | Semester | II | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | | 4 | - | - | | 4 | |
| Objectives of the course | <ul style="list-style-type: none"> • Describe the role of epidemiology in public health. • Explain about epidemiology tools and disease surveillance methods. • Analyze various communicable and non-communicable diseases in India. • Discuss on mechanism of antimicrobial resistance. • Outline on National health programmes that have been designed to address the issues. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Fundamentals and Historical aspects of epidemiology</p> <p>1.1 Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health.</p> <p>1.2 Natural history of disease - Historical aspects of epidemiology.</p> <p>1.3 Common risk factors - Epidemiologic Triad - Agent factors, host factors and environmental factors.</p> <p>1.4 Transmission basics - Chain of infection, portal of entry. Modes of transmission Direct and indirect. Stages of infectious diseases.</p> <p>1.5 Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission.</p> <p>1.6 Epidemiology of Zoonosis - Control of zoonosis.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Tools of epidemiology</p> <p>2.1 Tools of Epidemiology.</p> <p>2.2 Measures of Disease - Prevalence, incidence. Index case. Risk rates.</p> <p>2.3 Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures.</p> <p>2.4 Surveillance strategies - Disease surveillance.</p> <p>2.5 Geographical indication system.</p> <p>2.6 outbreak investigation in public health and contact investigation.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Pandemic diseases</p> <p>3.1 Epidemiological aspects of diseases of national importance - Background to communicable and non-communicable diseases.</p> | | | | | | |

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| | <p>3.2 Emerging disease threats – severe acute respiratory syndrome (SARS), Covid-19, Ebola, MDR-TB.</p> <p>3.3 Malaria, Mucor mycosis, Avian flu.</p> <p>3.4 Dengue, Swine Flu and Chikungunya.</p> <p>3.5 Epidemiology, prevention, and control of non-communicable diseases - Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders.</p> <p>3.6 Emerging and Re-emerging Diseases.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Antimicrobial resistance and nosocomial infection</p> <p>4.1 Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum β-lactamases (ESBL).</p> <p>4.2 Hospital acquired infections – an overview.</p> <p>4.3 Factors, infection sites, mechanisms and role of Multidrug resistant pathogens.</p> <p>4.4 Role of Pseudomonas, Acinetobacter, Clostridium difficile as Nosocomial pathogen.</p> <p>4.5 HBV, HCV, Rotavirus, Cryptosporidium and Aspergillus in Nosocomial infections.</p> <p>4.6 Prevention and management of nosocomial infections.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>National Programmes related to diseases</p> <p>5.1 National Programmes related to Communicable and Non-Communicable diseases.</p> <p>5.2 National Malaria Eradication Programme.</p> <p>5.3 Revised National Tuberculosis Control Programme.</p> <p>5.4 Vector Borne Disease Control Programme.</p> <p>5.5 National AIDS Control Programme.</p> <p>5.6 National Cancer Control Programme and National Diabetes Control Programme.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Dicker R., Coronado F., Koo. D. and Parrish. R. G. (2012). Principles of Epidemiology in Public Health Practice., (3rd Edition). CDC. 2. Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3rd Edition). Wiley Blackwell. 3. Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London. 4. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A. 5. Dimmok N. J. and Primrose S. B. (1994). Introduction to Modern Virology.5th edn. Blackwell Scientific Publishers. |

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| Reference Books | <ol style="list-style-type: none"> 1. Bhopal R. S. (2016). Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3rd Edition). Oxford University Press, New York. 2. Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6th Edition). Elsevier, USA. 3. Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press. 4. Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4th Edition), McGraw Hill, New York. 5. Topley W.W. C., Wilson, G. S., Parker M. T. and Collier L. H. (1998). Principles of Bacteriology. (9th Edition). Edward Arnold, London. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.scielo.br/j/rbca/a/mjDFGTtfWtBm786ZmR9TG9d/?lang=en 2. https://hal.archives-ouvertes.fr/hal-00902711/document 3. https://www.who.int/csr/resources/publications/whocdscsreph200212.pdf 4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/ 5. https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Apply the knowledge acquired on concepts of epidemiology to clinical and public health environment. |
| CO2 | Plan various strategies to trace the epidemiology. |
| CO3 | Plan the control of communicable and non-communicable diseases. |
| CO4 | Analyze the implications of drug resistance in the society and design the control of antimicrobial resistance and its management. |
| CO5 | Employ National control programs related to Communicable and Non-Communicable diseases with the public. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | M | M | M | H |
| CO4 | H | H | M | M | M | H |
| CO5 | H | H | L | M | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | L | M | H | L | H |
| CO3 | H | L | M | H | L | H |
| CO4 | H | L | M | H | L | H |
| CO5 | H | M | H | M | M | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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| Title of the Course | ELECTIVE III B: CLINICAL DIAGNOSTIC MICROBIOLOGY | | | | | |
| Paper No. | Elective Course III | | | | | |
| Category | Elective (Discipline centric) | Year | I | Credits | 3 | Course Code |
| | | Semester | II | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | |
| | 4 | - | - | | 4 | |
| Objectives of the course | <ul style="list-style-type: none"> • Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management. • Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab. • Elucidate various diagnostic procedures in microbiology. • Acquire knowledge on different methods employed to check antibiotic sensitivity. • Gain knowledge on hospital acquired infections and their control measures. | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microbiology laboratory safety practices</p> <p>1.1 Microbiology Laboratory Safety Practices - an overview. 1.2 General Safety Guidelines. 1.3 Types of wastes. 1.4 Handling of Biological Hazards materials. 1.5 Infectious health care waste disposal 1.6 Biomedical waste management.</p> | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Diagnostic procedures</p> <p>2.1 Specimens- Definition and an overview of common specimens collected for microbiological investigation. 2.2 General concept of Clinical specimen collection. 2.3 Specimen acceptance and rejection criteria. 2.4 Transport and storage of clinical specimens. 2.5 Diagnostic procedures. 2.6 General processing in Microbiology laboratory.</p> | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Immunological and molecular diagnosis</p> <p>3.1 Immunological and molecular diagnosis of microbial diseases – An overview 3.2 Agglutination and precipitation reactions.</p> | | | | | |

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| | <p>3.3 Haemagglutination and inhibition assays</p> <p>3.4 Automation in Microbial diagnosis.</p> <p>3.5 PCR and RFLP in diagnosis.</p> <p>3.6 NGS</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Antimicrobial sensitivity testing</p> <p>4.1 MIC and MBC- Definition.</p> <p>4.2 NCCLS</p> <p>4.3 Antibiotic sensitivity tests – Disc diffusion - Stokes and Kirby Bauer methods.</p> <p>4.4 Dilution - MBC/MIC.</p> <p>4.5 Quality control for antibiotics and standard strains.</p> <p>4.6 Antimicrobial resistance</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Nosocomial infections</p> <p>5.1 Nosocomial infections – Introduction and significance.</p> <p>5.2 Medically important nosocomial pathogens.</p> <p>5.3 Common types, sources, reservoir.</p> <p>5.4 Mode of transmission.</p> <p>5.5 Pathogenesis and control measures.</p> <p>5.6 Hospital Infection Control Committee (HICC) – Functions.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213. 2. Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15th Edition). Elsevier. ISBN:9780323681056. 3. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A. 4. Mukherjee K.L. (2000). Medical Laboratory Technology.Vol. 1-3. (2nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604. 5. Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6th Edition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496. |
| Reference Books | <ol style="list-style-type: none"> 1. Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Tenover F.C. (2003). Manual of Clinical Microbiology. (8th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4. 2. Bennett J. E., Dolin R. and Blaser M. J. (2019). Principles and Practice of Infectious Diseases. (9th Edition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554. |

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| | <ol style="list-style-type: none"> Ridgway G. L., Stokes E. J. and Wren M. W. D. (1987). Clinical Microbiology 7th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN 13:9780340554234. Koneman E.W., Allen S. D., Schreckenber P. C. and Winn W. C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378. Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press. ISBN-13:978-0-521-67631-1 / ISBN-10:0 521-67631-2. |
| Web resources | <ol style="list-style-type: none"> https://www.ncbi.nlm.nih.gov/books/NBK20370/ https://www.msmanuals.com/en-in/home/infections/diagnosis-of-infectious3disease/diagnosis-of-infectious-disease https://journals.asm.org/doi/10.1128/JCM.02592-20 https://www.sciencedirect.com/science/article/pii/S2221169116309509 http://www.textbookofbacteriology.net/normalflora_3.html |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Apply Laboratory safety procedures and hospital waste disposal strategies. |
| CO2 | Collect various clinical specimens, handle, preserve and process safely. |
| CO3 | Identify the causative agents of diseases by conventional and molecular methods following standard protocols. |
| CO4 | Assess the antimicrobial susceptibility pattern of pathogens. |
| CO5 | Trace the sources of nosocomial infection and recommend control measures. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | M | M | M | H |
| CO4 | H | H | M | M | M | H |
| CO5 | H | H | L | M | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | L | M | H | L | H |
| CO3 | H | L | M | H | L | H |
| CO4 | H | L | M | H | L | H |
| CO5 | H | M | H | M | M | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|------------------|--------------------|----------------|
| Title of the Course | ELECTIVE III C: BIOREMEDIATION | | | | | |
| Paper No. | Elective Course III | | | | | |
| Category | Elective (Discipline centric) | Year | I | Credits 3 | Course Code | PEMBI24 |
| | | Semester | II | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | Total | | |
| | 4 | - | - | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Describe the nature and importance of bioremediation and use in real world applications. • Describe the typical composition of waste water and application of efficient technologies for water treatment. • Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants. • Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics. • Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution. | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bioremediation and Bioaugmentation</p> <p>1.1 Bioremediation - process and organisms involved- Biofilm. 1.2 Bioaugmentation - Ex-situ and in-situ processes. 1.3 Intrinsic and engineered bioremediation. 1.4 Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. 1.5 Factors affecting the process. 1.6 Recent developments and significance.</p> | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Waste water treatment</p> <p>2.1 Microbes involved in aerobic and anaerobic processes in nature. 2.2 Water treatment, BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. 2.3 Secondary waste water treatments- use of membrane bioreactor. 2.4 Tertiary treatment. 2.5 Disposal of sewage and sludge 2.6 Disinfection.</p> | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Solid waste management</p> <p>3.1 Composting of solid wastes, anaerobic digestion - methane production and</p> | | | | | |

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| | <p>important factors involved.</p> <p>3.2 Pros and cons of anaerobic process, sulphur, iron and nitrate reduction,</p> <p>3.3 Hydrocarbon degradation.</p> <p>3.4 Degradation of nitroaromatic compounds.</p> <p>3.5 Bioremediation of dyes.</p> <p>3.6 Bioremediation in paper and pulp industries.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microbial leaching</p> <p>4.1 Microbial leaching of ores – process.</p> <p>4.2 Microorganisms involved and metal recovery with special reference to copper and iron.</p> <p>4.3 Biotransformation of heavy metals and xenobiotics.</p> <p>4.4 Petroleum biodegradation - reductive and oxidative.</p> <p>4.5 Dechlorination.</p> <p>4.6 Biodegradable of plastics and super bug.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Phytoremediation</p> <p>5.1 Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction.</p> <p>5.2 Phytodegradation.</p> <p>5.3 Phytovolatilization.</p> <p>5.4 Rhizodegradation.</p> <p>5.5 Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites.</p> <p>5.6 Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Bhatia H.S. (2018). A Text book on Environmental Pollution and Control. (2nd Edition). Galgotia Publications. 2. Chatterjee A. K. (2011). Introduction to Environmental Biotechnology. (3rd Edition). Printice-Hall, India. 3. Pichtel, J. (2014). Waste Management Practices: Municipal, Hazardous, and Industrial, 2nd edition, CRC Press. 4. Liu, D.H.F and Liptak, B.G (2005). Hazardous Wastes and Solid Wastes, Lewis Publishers. 5. Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1st edition. MJP Publishers |
| Reference Books | <ol style="list-style-type: none"> 1. Sangeetha J., Thangadurai D., David M. and Abdullah M.A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. (1st Edition). Apple Academic Press. |

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| | <ol style="list-style-type: none"> 2. Singh A. and Ward O. P. (2004). Biodegradation and Bioremediation. Soil Biology. 51 Springer. 3. Singh A., Kuhad R. C., and Ward O. P. (2009). Advances in Applied Bioremediation (1st Edition). Springer-Verlag Berlin Heidelberg, Germany. 4. Atlas, R.M & Bartha, R. (2000). Microbial Ecology. Addison Wesley Longman Inc. 5. Rathoure, A.K. (Ed.). (2017). Bioremediation: Current Research and Applications. 1st edition. I.K. International Publishing House Pvt. Ltd. |
| Web resources | <ol style="list-style-type: none"> 1. Bioremediation- Objective, Principle, Categories, Types, Methods, Applications (microbenotes.com) 2. https://agris.fao.org/agris-search 3. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation 4. https://www.intechopen.com/chapters/70661 https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Differentiate Ex-situ bioremediation / In-situ bioremediation and assess the roles of organisms in bioremediation. |
| CO2 | Distinguish microbial processes necessary for the design and optimization of biological processing unit operations. |
| CO3 | Identify, formulate and design engineered solutions to environmental problems. |
| CO4 | Explore microbes in degradation of toxic wastes and playing role on biological mechanisms. |
| CO5 | Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting Rhizobacteria in phytoremediation. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | L | L | M | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | M | M | H |
| CO5 | H | H | M | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | M | M | L | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | H | M | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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| Title of the Course | ELECTIVE IV A: BIOINFORMATICS | | | | | | |
| Paper No. | Elective Course IV | | | | | | |
| Category | Elective (Generic) | Year | I | Credits | 3 | Course Code | PEMBJ24 |
| | | Semester | II | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 4 | - | - | | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Discuss about various biological data mining concepts, tools. • Elucidate the principles and applications of sequence alignment methods and tools. • Demonstrate different phylogenetic tree construction methods and its uses in phylogenetic analysis. • Acquaint with various approaches in predicting 3D and 2D structure of proteins. • Describe various tools and techniques used in molecular docking, immunoinformatics and subtractive genomics. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biological Data mining</p> <p>1.1 Biological Data Mining – An overview. 1.2 Exploration of Data Mining Tools. 1.3 Cluster Analysis Methods. 1.4 Data Visualization. 1.5 Biological Data Management. 1.6 Biological Algorithms – Biological Primary and Derived Databases.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Phylogenetic and evolutionary trees</p> <p>2.1 Phylogenetic Tree Construction - Concept of Dendrograms. 2.2 Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances. 2.3 Reconstructing Trees from Additive Matrices. 2.4 Evolutionary Trees and Hierarchical Clustering - Character Based Tree 2.5 Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices. 2.6 Evolutionary models.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Computational protein structure</p> <p>3.1 Computational Protein Structure prediction. 3.2 Secondary structure.</p> | | | | | | |

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| | <p>3.3 Homology modelling.</p> <p>3.4 Fold recognition and ab initio 3D structure prediction.</p> <p>3.5 Structure comparison and alignment.</p> <p>3.6 Prediction of function from structure.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Ligand compounds</p> <p>4.1 Structural bioinformatics of ligands.</p> <p>4.2 Protein and Ligand interactions.</p> <p>4.3 Prediction of Properties of Ligand Compounds.</p> <p>4.4 Protein-ligand complex MD simulation</p> <p>4.5 3D Autocorrelation.</p> <p>4.6 Prediction of the Toxicity of Compounds.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Molecular docking</p> <p>5.1 Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction.</p> <p>5.2 Docking algorithms- Genetic, Lamarckian - Docking analyses.</p> <p>5.3 Molecular interactions- bonded and nonbonded</p> <p>5.4 Molecular Docking Software and Working Methods.</p> <p>5.5 Genome to drug discovery – Subtractive Genomics.</p> <p>5.6 Principles of Immunoinformatics and Vaccine Development.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Lesk A. M. (2002). Introduction to Bioinformatics. (4th Edition). Oxford University Press. 2. Lengauer T. (2008). Bioinformatics- from Genomes to Therapies (Vol-1). Wiley-VCH. 3. Rastogi S. C., Mendiratta N. and Rastogi P. (2014). Bioinformatics - Methods and Applications (Genomics, Proteomics and Drug Discovery) (4th Edition). Prentice-Hall of India Pvt.Ltd. 4. Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Addison Wesley Longman Limited, England. 5. Mount D.W., (2013). Bioinformatics sequence and genome analysis, 2nd edn. CBS Publishers, New Delhi. |
| Reference Books | <ol style="list-style-type: none"> 1. Baxevanis A. D. and Ouellette F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (2nd Edition). John Wiley and Sons. 2. Bosu O. and Kaur S. (2007). Bioinformatics - Database, Tools, and Algorithms. Oxford University Press. 3. David W. M. (2001). Bioinformatics Sequence and Genome Analysis (2nd Edition). CBS Publishers and Distributors (Pvt.) Ltd. 4. Xiong J, (2011). Essential bioinformatics, First south Indian Edition, Cambridge University Press. |

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| | 5. Harshawardhan P.Bal, (2006). Bioinformatics Principles and Applications, Tata McGraw-Hill Publishing Company Limited. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.hsls.pitt.edu/obrc/ 2. https://www.hsls.pitt.edu/obrc/index.php?page=dna 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1669712/ 4. https://www.ebi.ac.uk/ 5. https://www.kegg.jp/kegg/kegg2.html |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Access to databases that provides information on nucleic acids and proteins. |
| CO2 | Invent algorithms for sequence alignment. |
| CO3 | Construct phylogenetic tree. |
| CO4 | Predict the structure of proteins. |
| CO5 | Design drugs by predicting drug ligand interactions and molecular docking. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | L | L | H |
| CO2 | H | H | H | L | L | H |
| CO3 | H | H | H | L | L | H |
| CO4 | H | H | H | L | L | H |
| CO5 | H | H | H | L | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | H | H | L | H |
| CO4 | H | H | H | H | L | H |
| CO5 | H | H | H | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE IV B: NANOBIO TECHNOLOGY | | | | | | |
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| Paper No. | Elective Course IV | | | | | | |
| Category | Elective (Generic) | Year | I | Credits | 3 | Course Code | PEMBK24 |
| | | Semester | II | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 4 | - | - | | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Analyze nanomaterials based on the understanding of nanobiotechnology. • Discuss the methods of fabrication of nanomaterials. • Gain Knowledge on characterization of nanomaterials. • Discover nanomaterials for targeted drug delivery. • Explain nanomaterials in nanomedicine and environmental pollution. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Introduction to nanobiotechnology</p> <p>1.1 Introduction to nanobiotechnology. 1.2 Nano size-changing phenomena at nano scale. 1.3 Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) 1.4 Realization of their applications (The First, second, third and fourth generation materials). 1.5 Class of nanomaterials and their applications. 1.6 Need for nanomaterials and the risks associated with the materials.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Fabrication of nanomaterials</p> <p>2.1 Fabrication of Nanomaterials-Top-down and Bottom-up approaches. 2.2 Solid phase synthesis-milling. 2.3 Liquid phase synthesis-Sol-gel synthesis, colloidal synthesis, micro emulsion method. 2.4 Hydrothermal synthesis and solvo thermal synthesis. 2.5 Vapour/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. 2.6 Microbial synthesis of nanoparticles.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Characterization of nanoparticles</p> <p>3.1 Characterization of nanoparticles – Based on particle size/morphology, Dynamic light scattering (DLS). 3.2 Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM),</p> | | | | | | |

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| | <p>3.3 Surface charge-zeta potential–X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR).</p> <p>3.4 Energy dispersive X-ray analysis (EDX).</p> <p>3.5 Based on optical properties- UV – Spectrophotometer.</p> <p>3.6 Based on magnetic properties-Vibrating sample magnetometer (VSM).</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Nanomaterial based drug</p> <p>4.1 Nanomaterial based Drug delivery and therapeutics.</p> <p>4.2 Surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles.</p> <p>4.3 Lipid and inorganic nano particles for drug delivery.</p> <p>4.4 Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents.</p> <p>4.5 Toxicity of nanoparticles.</p> <p>4.6 Toxicity Evaluation.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Nanomaterials in diagnosis</p> <p>5.1 Nanotechnology in Health care.</p> <p>5.2 Nanomaterials in diagnosis.</p> <p>5.3 Imaging.</p> <p>5.4 Nanosensors in detection of pathogens.</p> <p>5.5 Uses of nanoparticles in MRI, DNA and Protein Microarrays.</p> <p>5.6 Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Brydson R. M., Hammond, C. (2005). Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology. John Wiley & Sons, Ltd. 2. Leggett G. J., Jones R. A. L. (2005). Bionanotechnology. In Nanoscale Science and Technology. John Wiley & Sons, Ltd. 3. Mohan Kumar G. (2016). Nanotechnology: Nanomaterials and nanodevices. Narosa Publishing House. 4. Goodsell D. S. (2004). Bionanotechnology. John Wiley & Sons, Inc. 5. Pradeep T. (2007). Nano: The Essentials-Understanding nanoscience and nanotechnology. Tata McGraw-Hill. |
| Reference Books | <ol style="list-style-type: none"> 1. Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley. 2. Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd. 3. Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience. 4. Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press. |

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| | 5. Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press |
| Web resources | <ol style="list-style-type: none"> 1. https://www.gale.com/nanotechnology 2. https://www.understandingnano.com/resources.html 3. http://dbtnanobiotech.com/index2.php 4. http://www.istl.org/11-winter/internet1.html 5. https://www.cdc.gov/niosh/topics/nanotech/default.html |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Employ knowledge in the field of nanobiotechnology for development. |
| CO2 | Identify various applications of nanomaterials in the field of medicine and environment. |
| CO3 | Examine the prospects and significance of nanobiotechnology. |
| CO4 | Identify recent advances in this area and create a career or pursue research in the field. |
| CO5 | Design non-toxic nanoparticles for targeted drug delivery. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | M | M | H |
| CO2 | H | H | H | L | L | M |
| CO3 | H | M | M | H | L | M |
| CO4 | H | M | H | H | M | M |
| CO5 | H | L | M | M | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | L | M | H |
| CO2 | H | H | H | L | L | M |
| CO3 | H | H | H | L | L | M |
| CO4 | H | H | H | M | M | M |
| CO5 | H | H | H | M | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|---|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE IV C: CLINICAL RESEARCH AND CLINICAL TRIALS | | | | | | |
| Paper No. | Elective Course IV | | | | | | |
| Category | Elective (Generic) | Year | I | Credits | 3 | Course Code | PEMBL24 |
| | | Semester | II | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 4 | - | - | | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Provide an overview of history and methods involved in conducting clinical research. • Design the principle involved in ethical, legal, and regulatory issues in clinical research on human subjects. • Describe principles and issues involved in monitoring patient-oriented research. • Formulate a well- defined quality assurance and quality control plans. • Acquire business development skills in the area of clinical research. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Introduction to clinical research</p> <p>1.1 Introduction to Clinical Research: Clinical Research - An Overview. 1.2 Terminologies and definition in Clinical Research. 1.3 Different types of Clinical Research. 1.4 Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence. 1.5 Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. 1.6 Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV).</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Clinical Ethics</p> <p>2.1 Ethical Considerations and Guideline in Clinical Research - Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. 2.2 International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. 2.3 Regulation in Clinical Research Drug and cosmetic act, FDA, Schedule-Y-Ethics Committee and their responsibilities. 2.4 Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. 2.5 DCGI submission procedure. 2.6 Other Regulatory authorities- EMEA, MHRA, PhRMA.</p> | | | | | | |

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| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Clinical Trial Management</p> <p>3.1 Clinical Trial Management- An overview. 3.2 Key Stakeholders in Clinical Research. 3.3 Ethics Committees and Institutional Review Board, Responsibilities of Sponsor. 3.4 Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements. 3.5 Informed Consent, Investigator’s Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. 3.6 Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Quality control and monitoring</p> <p>4.1 Defining the terminology- Quality, Quality system, Quality Assurance & Quality Control. 4.2 Quality Assurance, Quality Control & Clinical Monitoring and its significance. 4.3 QA audit plan. 21 CFR Part 11, Site Auditing, Sponsor Compliance and Auditing. 4.4 SOP For Clinical Research -CRF Review. 4.5 Source Data Verification, 4.6 Drug Safety Reporting Corrective and Preventative action process.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Clinical research industry</p> <p>5.1 Business Development in the Clinical Research Industry: Introduction . 5.2 Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. 5.3 Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, 5.4 List of Clinical Research Organizations in India. 5.5 List of IT companies offering services in Clinical Research. 5.6 Role of business development manager.</p> |
| <p>Text Books</p> | <ol style="list-style-type: none"> 1. Gallin J. I., Ognibene F. P. and Johnson L. L. (2007). Principles and Practice of Clinical Research. (4th Edition). Elsevier, 2007.ISBN-10: 0128499052 2. Friedman L. M., Furberg C. D. and Demets D. (1998). Fundamentals of Clinical Trials, Vol: XVIII. (3rd Edition). Springer Science & Business Media. |

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| | <ol style="list-style-type: none"> 3. Hulley S. B., Cummings S. R., Browner W. S., Grady D. G. and Newman T. B. (2013). Designing Clinical Research. (4th Edition). Jaypee Medical. ISBN-13: 978 1608318049. 4. Reed,G. (2004). Prescott and Dunn’s Industrial Microbiology, 4th edn, CBS publication and distributors. 5. Himanshu B. (2010). Text book of Clinical Research, Pee Vee books. |
| Reference Books | <ol style="list-style-type: none"> 1. Friedman L.M., Fuberge C.D., DeMets D. and Reboussen, D.M. (2015). Fundamentals of Clinical Trials, Springer. 2. Browner W. S., (2012). Publishing and Presenting Clinical Research. (3rd Edition). Lippincott Williams and Wilkins. 3. Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2nd Edition). Wiley. 4. Pepler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2nd Edition Academic Press, London. 5. E1-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman,A.R. (2007). Fermentation Microbiology and Biotechnology. 2nd Edition, CRC press, Taylor and Francis Group. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.hzu.edu.in/uploads/2020/10/Textbook-of-Clinical-Trials-Wiley(2004).pdf 2. https://www.routledge.com/A-Practical-Guide-to-Managing-Clinical-Trials/Pfeiffer+Wells/p/book/9780367497828 3. https://www.auctoresonline.org/journals/clinical-research-and-clinical-trials 4. https://www.who.int/health-topics/clinical-trials#tab=tab_1 5. https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/what-clinical-trials-are/types-of-clinical-trials/ |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Apprehend the Drug Development process and different phases of clinical trials. |
| CO2 | Recognize the ethics and regulatory perspectives on clinical research trials activities. |
| CO3 | Accentuate about clinical trials management concepts and documentation process. |
| CO4 | Accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trial results. |
| CO5 | To nurture skills recitation to commercial start up and industriousness. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | M | M | H |
| CO2 | H | H | M | L | L | H |
| CO3 | H | M | L | H | M | H |
| CO4 | H | M | L | H | M | H |
| CO5 | H | H | M | M | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | L | H | H |
| CO2 | H | H | H | M | L | H |
| CO3 | H | H | H | L | M | H |
| CO4 | H | M | H | L | M | H |
| CO5 | H | H | H | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|---|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | SEC: VERMITECHNOLOGY | | | | | | |
| Paper No. | Skill Enhancement Course [SEC I] | | | | | | |
| Category | Skill Enhancement | Year | I | Credits | 2 | Course Code | PSMB124 |
| | | Semester | II | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 2 | - | - | | 2 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Introduce the concepts of vermicomposting. • Explain the physiology, anatomy and biology of earthworms. • Acquire the knowledge of the vermicomposting process. • Explain the trouble shooting, harvesting and packaging of vermin composts. • Gain knowledge on applications of vermin composts and their value-added products. | | | | | | |
| Course Outline | <p>UNIT I (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Vermiculture – an introduction</p> <p>Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Its role in the bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.</p> | | | | | | |
| | <p>UNIT II (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Earthworm biology</p> <p>Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of Eisenia fetida. a) Taxonomy Anatomy, physiology and reproduction of Lumbricidae. b) Vital cycle of Eisenia fetida: alimentation, fecundity, annual reproducer potential and limiting factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Biology of Eudrilus eugeniae. c) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. d) Vital cycle of Eudrilus eugeniae: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).</p> | | | | | | |
| | <p>UNIT III (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Vermicomposting</p> <p>Vermicomposting Process - Feeds for Vermitech systems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre composting phase-</p> | | | | | | |

| | |
|------------------------|--|
| | Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system. |
| | <p>UNIT IV (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Factors affecting vermicomposting</p> <p>Vermicomposting - Trouble Shooting-Temperature-Aeration- Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques- Light Separation-Sideways Separation-Vertical Separation Gradual transfer. Harvesting Earthworms- manual method- migration method. Packing & Nutritional analysis of vermicompost.</p> |
| | <p>UNIT V (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Application of vermiculture</p> <p>Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields- crops, fruits, vegetables & flowers. By-products and value-added products- Verm wash-vermicompost tea-vermi meal enriched vermicompost-pelleted vermicompost.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India. 2. Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd. 3. Christy M. V. (2008). Vermitechnology, (1st Edition), MJP Publishers. 4. Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide. |
| Reference Books | <ol style="list-style-type: none"> 1. Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing. 2. Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi. 3. Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1st edn.CRC Press. 4. Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1st edn. Orient longman. |
| Web resources | <ol style="list-style-type: none"> 1. https://en.wikipedia.org/wiki/Vermicompost 2. http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf 3. https://www.kngac.ac.in/elearning_portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf 4. https://composting.ces.ncsu.edu/vermicomposting-2/ 5. https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/ |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Compare and contrast the uses of vermicompost to the soil. |
| CO2 | Recommend different species of earthworms after acquiring knowledge on its biology. |
| CO3 | Design the vermicomposting process. |
| CO4 | Assess the Best Practices of Vermicomposting |
| CO5 | Recommend the applications of vermicompost to different soils and for different crops. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | M | L | M | M | H |
| CO3 | H | M | L | M | M | H |
| CO4 | H | M | H | H | H | H |
| CO5 | H | L | M | L | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | M | L | M | L | H |
| CO3 | H | M | L | M | L | H |
| CO4 | H | M | H | H | L | H |
| CO5 | H | L | M | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | SOIL AND ENVIRONMENTAL MICROBIOLOGY | | | | | | |
| Paper No. | Core Course VII | | | | | | |
| Category | Core | Year | II | Credits | 5 | Course Code | PCMBG24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Explain the role of microorganisms in soil fertility. • Discuss the benefits of interactions among soil microbes and acquire awareness about microbes as biofertilizers and biocontrol agents. • Create awareness. about components of environment, environmental pollution, and detection methods. • Acquire in depth knowledge about solid and liquid waste treatments. • Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Soil Microbiology</p> <p>1.1 Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation.</p> <p>1.2 Diversity and distribution of major group of microorganisms in soil.</p> <p>1.3 Quantification of soil microflora.</p> <p>1.4 Role of microorganism in soil fertility.</p> <p>1.5 Mineralization of Organic & Inorganic Matter in Soil.</p> <p>1.6 Biological Nitrogen fixation- Chemistry and Genetics of BNF.</p> | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microbial interactions</p> <p>2.1 Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition.</p> <p>2.2 Rhizosphere- Rhizosphere effect.</p> <p>2.3 Mycorrhizae – Types, Endophytes.</p> <p>2.4 PGPR- Plant growth promoting bacteria– symbiotic (Bradyrhizobium, Rhizobium, Frankia).</p> <p>2.5 Non-Symbiotic (Azospirillum, Azotobacter, Mycorrhizae, MHBs, Phosphate solubilizers, algae).</p> <p>2.6 Novel combination of microbes as biofertilizers, PGPRs.</p> | | | | | | |

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| | <p>UNIT III (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Environmental components</p> <p>3.1 Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples.</p> <p>3.2 Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles.</p> <p>3.3 Physical factors affecting distribution of microorganisms in various environments.</p> <p>3.4 Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases.</p> <p>3.5 Treatment and safety of drinking (potable) water, methods to detect potability of water samples.</p> <p>3.6 Space microbiology - Microbiological research in space environment.</p> |
| | <p>UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Waste Management</p> <p>4.1 Waste management – Solid waste - Types - management.</p> <p>4.2 Factors affecting solid waste generation rates.</p> <p>4.3 Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process.</p> <p>4.4 Quality assessment of decontaminated matters and other biological effluents. Biological reference standards.</p> <p>4.5 Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production.</p> <p>4.6 E waste management.</p> |
| | <p>UNIT V (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biodegradation</p> <p>5.1 Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4-D) and pesticides (DDT), heavy metals.</p> <p>5.2 Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers.</p> <p>5.3 Biodegradation of Hydrocarbons.</p> <p>5.4 Biodeterioration of Textiles and Leather.</p> <p>5.5 Pollution Control Bodies and Environmental laws in India.</p> <p>5.6 Environmental impact assessment, EIA guidelines, US Environment protection Agency norms.</p> |
| <p>Text Books</p> | <ol style="list-style-type: none"> 1. Subba Rao. N. S. (2017). Soil Microbiology. (5th Edition). MedTech Publishers. 2. Daniel. C. J. (2006). Environmental Aspects of Microbiology. (2nd Edition). Bright Sun Publications. 3. Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd. 4. Sharma P. D. (2010). Microbiology and Plant pathology. (2nd Edition). Rastogi Publications. 5. Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd. |

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| Reference Books | <ol style="list-style-type: none"> 1. Pepper I. L., Gerba C. P. and Gentry T. J. (2014). Environmental Microbiology (1st Edition). Academic Press, Elsevier. 2. Bitton, G. (2011). Wastewater Microbiology. (4th Edition). Wiley-Blackwell. 3. Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association. 4. Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation. 5. Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan. |
| Web resources | <ol style="list-style-type: none"> 1. https://academic.oup.com/femsec/article/93/5/fix044/3098413 2. http://www.fao.org/3/t0551e/t0551e05.htm 3. www.environmentshumail.blogspot.in/ 4. https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full 5. https://serc.carleton.edu/microbelife/index.html |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation. |
| CO2 | Utilize the knowledge of microbial interactions, with beneficial application of biofertilizers for sustainable agriculture and benefits of biopesticides. |
| CO3 | Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases. |
| CO4 | Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup. |
| CO5 | Plan a clear approach on environmental issues, control pollution and explain protection laws to public. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | L | L | M | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | M | M | H |
| CO5 | H | H | M | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | M | M | L | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | H | M | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | MOLECULAR BIOLOGY AND RECOMBINANT DNA TECHNOLOGY | | | | | | |
| Paper No. | Core Course VIII | | | | | | |
| Category | Core | Year | II | Credits | 5 | Course Code | PCMBH24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Provide knowledge on the structure, replication and repair mechanisms of DNA. Illustrate the structure, functions and significance of RNA. • Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations. • Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants. • Impart knowledge on various molecular techniques and their importance in biotechnology. • Explain the applications of genetic engineering in various fields. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>DNA replication</p> <ol style="list-style-type: none"> 1.1 DNA replication – modes and enzymes involved. 1.2 Detailed mechanism of semi-conservative replication. 1.3 Prokaryotic and eukaryotic transcription. 1.4 Structure and processing of m-RNA, r RNA and t-RNA. 1.5 Ribosomes and its functions. 1.6 Genetic Code and Wobble hypothesis. | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Gene expression system and mutation</p> <ol style="list-style-type: none"> 2.1 Gene regulation and expression – Lac operon and tryptophan operon. 2.2 Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. 2.3 Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion, Silent, conditional and lethal mutation. 2.4 Chemical mutagenesis. 2.5 Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. 2.6 Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test). | | | | | | |

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| | <p>UNIT III (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Gene cloning techniques and Vectors</p> <p>3.1 Tools and methods in gene cloning.</p> <p>3.2 Restriction endonucleases – nomenclature, classification and characteristics - DNA methylases, DNA polymerases, Ligases. Adapters, linkers and homopolymer tailing.</p> <p>3.3 Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment.</p> <p>3.4 Screening for recombinants.</p> <p>3.5 Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors) - Phage Vectors (M13 and Lambda), cosmids and BACs .</p> <p>3.6 Eukaryotic vectors - Yeast vectors YIP, YRP and YAC. Plant vectors (Ti plasmids) – expression vectors. Shuttle vectors.</p> |
| | <p>UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>4.1 Genomic DNA and cDNA library - Construction and Screening.</p> <p>4.2 Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping.</p> <p>4.3 Restriction fragment length polymorphism (RFLP).</p> <p>4.4 Polymerase chain reaction (PCR) – types and their applications.</p> <p>4.5 DNA sequencing - Primer walking, Sanger’s method and automated sequencing methods.</p> <p>4.6 Pyrosequencing – DNA chips and micro array.</p> |
| | <p>UNIT V (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Plant and Animal Biotechnology</p> <p>5.1 Transgenic plants and transgenic animals – introduction.</p> <p>5.2 Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion.</p> <p>5.3 Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - Recombinant Cytokines and their use in the treatment of animal infections.</p> <p>5.4 Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections.</p> <p>5.5 Human Gene Therapy - Germline and Somatic Cell Therapy - Ex-vivo Gene Therapy. In-vivo Gene Therapy.</p> <p>5.6 Vectors in Gene Therapy-Viral and Non-Viral Vectors.</p> |

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| Text Books | <ol style="list-style-type: none"> 1. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi. 2. Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7th Edition). John Wiley and Soms, Inc. 3. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. 4. Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7th Edition). Blackwell Publishing. 5. Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing House Pvt. Ltd. |
| Reference Books | <ol style="list-style-type: none"> 1. Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7th Edition). John Wiley and Sons, Ltd. 2. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press. 3. Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition. 4. Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of Bacteria. (4th Edition). ASM Press Washington-D.C. ASM Press. 5. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. |
| Web resources | <ol style="list-style-type: none"> 1. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ 2. https://geneticeducation.co.in/what-is-transcriptomics 3. https://www.molbiotools.com/usefullinks.html 4. https://geneticeducation.co.in/what-is-transcriptomics 5. https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/ |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Analyze, demonstrate and appreciate DNA replication and protein synthesis. |
| CO2 | Investigate the types of mutation and its impact on microbes. Illustrate various strategies on gene cloning. |
| CO3 | Analyze, modify and characterize DNA modifying enzymes. |
| CO4 | Illustratively assess the molecular techniques for DNA and protein analysis. |
| CO5 | Adopt the applications of Genetic Engineering in the field of agriculture and medicine towards scientific research. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | M | L | M |
| CO2 | H | H | H | L | L | M |
| CO3 | H | H | H | M | M | L |
| CO4 | H | H | H | H | M | M |
| CO5 | H | H | H | L | L | M |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | L | L | H |
| CO2 | H | H | H | L | M | H |
| CO3 | H | H | H | L | M | M |
| CO4 | H | H | H | M | L | H |
| CO5 | H | H | H | L | M | M |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|---|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | PRACTICAL III: APPLIED MICROBIOLOGY | | | | | | |
| Paper No. | Core Course IX | | | | | | |
| Category | Practical | Year | II | Credits | 5 | Course Code | PCMBI24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | - | - | 6 | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Examine Air borne microbes. • Enumerate microorganisms from food. • Analyze and estimate water quality and potability. • Prepare Biofertilizers, vermicompost and test their efficiency. • Familiarize with common plant infections. | | | | | | |
| Course Outline (Experiments) | <ol style="list-style-type: none"> 1. Enumeration of bacteria and fungi from air – Air sampler and settle plate technique. 2. Microbiological analysis of water and Test for indicative organisms - 1) MPN 2) Membrane Filtration. 3. Enumeration of Microorganism from food sample – Lactobacillus and Staphylococcus from curd, bacteria and yeast from food. 4. MBRT/ Resazurin test for identifying quality of milk sample. 5. Isolation of free-living nitrogen fixers from soil and Rhizobium from root nodules of leguminous plants. 6. Isolation and enumeration of phosphate-solubilizing bacteria from soil. 7. Estimation of soil enzymes- urease and phosphatase. 8. Study of phylloplane microflora by leaf impression method. 9. Isolation of cellulose degrading bacteria. 10. Preparation of a vermicompost. 11. Isolation of VAM fungi from soil (Demonstration). 12. Cultivation of edible mushroom from solid waste 13. Cultivation of Azolla 14. Visual examination, observation, and identification of some common plant infections. Collection of 5 herbarium specimens of infected leaves. | | | | | | |
| Text Books | <ol style="list-style-type: none"> 1. Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International. 2. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York. 3. Dubey, R.C. and Maheshwari, D.K. (2002) Practical Microbiology, 1st Edn. S. Chand & Co. Ltd., New Delhi. 4. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology. | | | | | | |

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| Reference Books | <ol style="list-style-type: none"> 1. Cappuccino J. and Sherman N. (2002) Microbiology: A Laboratory Manual, 6th Edn. Pearson Education Publication, New Delhi. 2. Gerhardt P., Murray R.G., Wood W.A. and Kreig N.R. (1994) Methods for General and Molecular Bacteriology. ASM Press, Washington, DC. 3. Pepper I., Gerba C. and Bredecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier. 4. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley. |
| Web resources | <ol style="list-style-type: none"> 1. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet. https://vlab.amrita.edu/index.php?sub=3&brch=272 2. https://nptel.ac.in/courses/102105087 3. www.aview.in/aview 4. www.pbs.org 5. www.micro.magnet.fsu.edu/primer/java/scienceopticsu |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Utilize Air samplers for assessment of air quality. |
| CO2 | Undertake protocols in identifying food borne pathogens. |
| CO3 | Assess the microbial quality of water and air and relate the results to standards. |
| CO4 | Synthesize biofertilizers and vermicompost. Cultivate mushrooms using solid waste. |
| CO5 | Identify various plant pathogens |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | H | L | H |
| CO2 | H | H | H | L | M | H |
| CO3 | H | H | M | M | L | H |
| CO4 | L | H | H | H | L | H |
| CO5 | L | H | M | L | M | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | M | M | H | L | H |
| CO2 | H | H | H | L | L | H |
| CO3 | H | M | M | M | L | H |
| CO4 | H | M | H | H | L | H |
| CO5 | H | M | M | L | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | FERMENTATION TECHNOLOGY AND PHARMACEUTICAL MICROBIOLOGY | | | | | | |
| Paper No. | Core Course X | | | | | | |
| Category | Core (Industry module) | Year | II | Credits | 4 | Course Code | PCMBJ24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Discuss about fermentation and its types, sensitize on methods of strain development for improved yield. • Impart knowledge on the fermenter design and types. • Acquire knowledge on the effective recovery and purification of the products. • Explain the importance of pharmaceutical microbiology. • Illustrate methods for production products using microorganisms and their quality control. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Fermentation and types of fermentation</p> <p>1.1 Bioprocesses - concepts and design. 1.2 Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. 1.3 Upstream processing - Development of inoculums for fermentation process. 1.4 Media for industrial fermentation - Formulation, optimization. Sterilization. 1.5 Stages of upstream - Growth of inoculums, fermenter pre culture and production fermentation. 1.6 Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.</p> | | | | | | |
| | <p>UNIT II (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bioreactor and its types</p> <p>2.1 Fermenter – Design, types and construction, Instrumentation and control. 2.2 Productivity. Yield coefficients. Heat production. 2.3 Aeration and agitation. 2.4 Gas exchange and mass transfer. 2.5 Computer Applications in fermentation technology. 2.6 Fermentation Economics.</p> | | | | | | |

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| | <p>UNIT III (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Downstream processing</p> <p>3.1 Downstream Processing – an overview.</p> <p>3.2 Recovery and purification of intracellular and extracellular products.</p> <p>3.3 Biomass separation by centrifugation, filtration, flocculation and other recent developments.</p> <p>3.4 Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction.</p> <p>3.5 Purification by different methods.</p> <p>3.6 Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.</p> |
| | <p>UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Introduction to Pharmaceutical Microbiology</p> <p>4.1 Overview of pharmaceutical microbiology.</p> <p>4.2 Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment.</p> <p>4.3 Microbial control measures.</p> <p>4.4 Design and layout of sterile manufacturing unit.</p> <p>4.5 Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable.</p> <p>4.6 Ophthalmologic preparation, implants.</p> |
| | <p>UNIT V (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Pharmaceutical products and quality assurance</p> <p>5.1 Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnosics, immuno-sera, immunoglobulin.</p> <p>5.2 Antibiotics - Penicillin, Griseofulvin, Metronidazole.</p> <p>5.3 Enzymes - Streptokinase, Streptodornase.</p> <p>5.4 Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control.</p> <p>5.5 Sterility tests.</p> <p>5.6 Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.</p> |
| <p>Text Books</p> | <ol style="list-style-type: none"> 1. Patel A. H. (2016). Industrial Microbiology. (2nd Edition). Laxmi Publications, New Delhi. 2. Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers. 3. Sathyanarayana U. (2005). Biotechnology. (1st Edition). Books and Allied (P) Ltd. |

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| | <ol style="list-style-type: none"> 4. Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4th Edition). CBS Publishers & Distributors. 5. Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers. |
| Reference Books | <ol style="list-style-type: none"> 1. Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY. 2. Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). Vallabh Prakashan Publishers, New Delhi. 3. Kokate C. K., Durohit A. P. and Gokhale S. R. (2002). Pharmacognosy. (12th Edition). Nirali Prakasham Publishers, Pune. 4. Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford. 5. Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi. |
| Web resources | <ol style="list-style-type: none"> 1. https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html 2. https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html 3. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/ethanol-fermentation 4. https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf 5. http://www.simbhq.org/ |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Develop microbial strains, carry out fermentation and recover the products of the process. |
| CO2 | Design fermenters according to needs for various products. |
| CO3 | Recover the end products of the fermentation process economically. |
| CO4 | Utilize the knowledge on pharmaceutical microbiology for industrial production of products. |
| CO5 | Produce therapeutic products from microbes employing technology and analyze the quality the products. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | M | H |
| CO2 | H | M | M | L | H | H |
| CO3 | H | M | M | L | H | H |
| CO4 | H | M | M | L | H | H |
| CO5 | H | H | H | L | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | M | H |
| CO2 | H | M | M | H | H | H |
| CO3 | H | M | M | H | H | H |
| CO4 | H | M | M | H | H | H |
| CO5 | H | H | H | H | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE V A: BIOSAFETY, BIOETHICS AND IPR | | | | | | |
| Paper No. | Elective Course V | | | | | | |
| Category | Elective (Discipline centric) | Year | II | Credits | 3 | Course Code | PEMBM24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 3 | - | - | | 3 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Create a research environment. Encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine. • Discuss about various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products. • Familiarize fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries. • Acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops. • Provide students with an understanding of bioethics in research associated with medicine | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Intellectual Property Rights</p> <p>1.1 Intellectual Property Rights: An overview. 1.2 Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. 1.3 Role of IPR’s in Biotechnology. 1.4 Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. 1.5 Patent life and geographical boundaries. 1.6 International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Patenting</p> <p>2.1 Process involved in patenting. 2.2 Patent Search - Procedural steps in patenting. 2.3 Process of filing, PCT application, pre grant & post-grant opposition. 2.4 PCT and patent harmonization including Sui-generis system, patent search methods, patent databases and libraries, online tools 2.5 Country-wise patent searches (USPTO, EPO, India etc).</p> | | | | | | |

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| | 2.6 Patent mapping. |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>World Patent System</p> <p>3.1 Patentability of biotechnology inventions - Patentability of biotechnology inventions in India.</p> <p>3.2 Statutory provisions regarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005).</p> <p>3.3 Biotechnological inventions as patentable subject matter, territorial nature of patents - from territorial to global patent regime, interpreting trips in the light of biotechnology inventions.</p> <p>3.4 Feasibility of a uniform global patent system, merits and demerits of uniform patent law.</p> <p>3.5 Relevance of the existing international patent, tentative harmonisation efforts.</p> <p>3.6 Implications of setting up a uniform world patent system.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bioethics and Biodiversity</p> <p>4.1 Introduction to bioethics - need of bioethics, applications.</p> <p>4.2 Issues related to bioethics, social and cultural issues.</p> <p>4.3 Bioethics and biodiversity - conserving natural biodiversity.</p> <p>4.4 Convention on protecting biodiversity.</p> <p>4.5 Protocols in exchanging biological material across borders.</p> <p>4.6 Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene pool.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bioethics in medicine</p> <p>5.1 Bioethics in medicine – An overview.</p> <p>5.2 Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation.</p> <p>5.3 Ethics in patient care, informed consent. bioethics and cloning.</p> <p>5.4 Permissions and procedures in animal cloning, human cloning- risks and hopes.</p> <p>5.5 Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races.</p> <p>5.6 The Nuremberg code.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Usharani B., Anbazhagi S. and Vidya C. K. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN-10 1645878856 2. Satheesh M. K. (2009). Bioethics and Biosafety. (1st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703 |

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| | <ol style="list-style-type: none"> Goel D. and Parashar S. (2013). IPR, Biosafety and Bioethics. (1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700 Raj Mohan joshi. (2002). Biosafety and Bioethics. Wiley Publications. Sibi. G. (2021) Intellectual, Property Rights, Bioethics, Biosafety and Entrepreneurship in biotechnology. Wiley Publications. |
| Reference Books | <ol style="list-style-type: none"> Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India, IN: Cengage Learning India Private Limited. Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights, India, IN: PHI learning Private Limited. Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis. Tony Hope (2004). Medical Ethics: A very Short introduction,. Oxford Publication. Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications. |
| Web resources | <ol style="list-style-type: none"> http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf. https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf. https://www.cdc.gov/training/quicklearns/biosafety/ https://bioethics.msu.edu/what-is-bioethics https://www.wto.org/english/tratop_e/trips_e/intell1_e.htm |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Execute the role of IPR, Patent, Trademarks and its importance. |
| CO2 | Develop patent procedure, patent filling and its mapping. |
| CO3 | Become Patent attorneys and Patent officers. |
| CO4 | Apply bioethics in GMO, food crops and its biodiversity. |
| CO5 | Analyze the importance of bioethics in research associated with HGP, clinical research, stem cell therapy. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|--------|------|------|------|------|------|------|
| CO1 | H | H | M | M | M | H |
| CO2 | H | H | M | L | L | H |
| CO3 | H | M | L | H | M | H |
| CO4 | H | M | L | H | M | H |
| CO5 | H | H | M | M | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-------|-----|-----|-----|-----|-----|-----|
| CO1 | H | H | H | L | H | H |
| CO2 | H | H | H | M | L | H |
| CO3 | H | H | H | L | M | H |
| CO4 | H | M | H | L | M | H |
| CO5 | H | H | H | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | ELECTIVE V B: ENTREPRENEURSHIP AND MANAGEMENT IN MICROBIAL TECHNOLOGY | | | | | | |
| Paper No. | Elective Course V | | | | | | |
| Category | Elective (Discipline centric) | Year | II | Credits | 3 | Course Code | PEMBN24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 3 | - | - | | 3 | | |
| Objectives of the course | <ul style="list-style-type: none"> • To provide basic concepts of management such as planning, decision making, leadership, organization and authority. • To understand the motivational theories. • To explain the concepts of centralization and decentralization. • To discuss on IPR and Bioethics with an understanding of government policies. • To attain skill to manage start up and run an organization. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Understanding management and administration.</p> <p>1.1 Understanding management and administration. 1.2 Management: Nature and scope. 1.3 Management: functional aspects/areas. 1.4 Evolution of management thought: early, contemporary and modern. 1.5 Roles of Management. 1.6 Levels of managements.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Major components of management skills.</p> <p>2.1 Major component of management skills. 2.2 Planning: nature, purpose and importance. 2.3 Types of plans. 2.4 Steps in planning & planning premises. 2.5 Hierarchy of plans. 2.6 Components of planning, Decision making.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Motivational theories.</p> <p>3.1 Leadership Meaning and nature of directing. 3.2 Understanding, Supervision, motivation. 3.3 Leadership styles, Motivation Theories (Abraham Maslo, Herzberg and Victor Hvrom's). 3.4 Communication – Meaning and importance. 3.5 Meaning and steps in controlling – Essentials of a control system. 3.6 Methods of establishing control (in brief).</p> | | | | | | |

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| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Centralization Vs Decentralization.</p> <p>4.1 Centralization Vs Decentralization of authority and responsibility.</p> <p>4.2 Nature and importance of staffing–Process of Recruitment and Selection.</p> <p>4.3 Organisation: nature and purpose.</p> <p>4.4 Principles of organization.</p> <p>4.5 Types of organization.</p> <p>4.6 Departmental Committees.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Structure of biobased technology company.</p> <p>5.1 Structure of a Bio based technology Company.</p> <p>5.2 Start-up of Bio based technology Company.</p> <p>5.3 New Product Development.</p> <p>5.4 Market Research.</p> <p>5.5 Capital and source investors.</p> <p>5.6 Sales & Marketing Principles.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Naidu, NVR. (2013) Management and Entrepreneurship. 1st edn. I. K. International Pvt Ltd. 2. Tripathi, PC., Reddy, PN. (2008) Principles of Management. Tata McGraw Hill. 3. Desai V. (2004). Dynamics of Entrepreneurial Development & Management– Vasant Desai – Himalaya Publishing House 4. Charantimath , PM. (2006) Entrepreneurship Development Pearson Education – 2006 5. Thomson Robbins, S. (2003) Entrepreneurship Development– 17th Edition - Pearson Education/PHI |
| Reference Books | <ol style="list-style-type: none"> 1. Craig Shimasaki. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Academic Press. 2. Peter F. Drucker (2006). Innovation and Entrepreneurship. Harper Business publisher. 3. Leah Cannon (2017). How to Start a Life Science Company: A Comprehensive Guide for First-Time Entrepreneurs. International Kindle paperwhite. 4. Charles E. Bamford, Garry D. Bruton (2015). Entrepreneurship: The Art, Science, and Process for Success, 2nd Edition, McGraw Hill publisher. 5. Yali Friedman (2014). Building Biotechnology: Biotechnology Business, Regulations, Patents, Law, Policy and Science 4th Edition, Logos press publication. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.bio-rad.com/webroot/web/pdf/lse/literature/Biobusiness.pdf 2. https://www.crg.eu/biobusiness-entrepreneurship 3. https://www.entrepreneur.com 4. https://www.birac.nic.in 5. https://www.springer.com |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Acquaint basic concepts of management such as planning, decision making, leadership, organization and authority. |
| CO2 | Compile the motivational theories. |
| CO3 | Explain the concepts of centralization and decentralization. |
| CO4 | Discuss on IPR and Bioethics with an understanding of government policies. |
| CO5 | Attain skill to manage start up and run an organization. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | M | H |
| CO2 | H | M | M | L | H | H |
| CO3 | H | M | M | L | H | H |
| CO4 | H | M | M | L | H | H |
| CO5 | H | H | H | L | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | M | H |
| CO2 | H | M | M | H | H | H |
| CO3 | H | M | M | H | H | H |
| CO4 | H | M | M | H | H | H |
| CO5 | H | H | H | H | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE V C: WATER CONSERVATION AND WATER TREATMENT | | | | | | |
|------------------------------|--|----------|--------------|---------|---|-------------|---------|
| Paper No. | Elective Course V | | | | | | |
| Category | Elective (Discipline centric) | Year | II | Credits | 3 | Course Code | PEMBO24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | Total | | | |
| | 3 | - | - | 3 | | | |
| Objectives of the course | <ul style="list-style-type: none"> • Explain how societal and climatic changes will distress water supply and water demand in future. • Ascertain promising elucidations to the global water crisis and assess the pros and cons. • Acquire knowledge to identify the quality of water by standard method. • Illustrate the methods of water treatment technologies and assessing the impact of HWTS. • Describe the application and uses of various emerging water treatment technologies. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Water Scarcity</p> <p>1.1 Water Scarcity; Major Causes of Water Scarcity, 1.2 Types of Water Scarcity, Water Footprint. 1.3 Effects of Water Scarcity Across the Globe. 1.4 Water Scarcity in India. 1.5 Effects of Water Scarcity in India. 1.6 Social and Political Effects and Economic Risks of Water Scarcity in India.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Approach for prevention of water scarcity</p> <p>2.1 Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging. 2.2 Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir. 2.3 Desalination Plants Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana. 2.4 Adoption of Composite Water Management Index (CWMI). 2.5 Water conservation resource management. 2.6 Rain Water Harvesting.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Water quality and pollution</p> <p>3.1 Water Quality and Pollution; Impurities in the water. 3.2 Characteristics of different water sources, vulnerability of the water sources to</p> | | | | | | |

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| | <p>contamination.</p> <p>3.3 Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater.</p> <p>3.4 Water quality standards.</p> <p>3.5 Microbiological quality of drinking Water.</p> <p>3.6 Chemical quality of drinking water.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Water treatment</p> <p>4.1 Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation.</p> <p>4.2 Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration.</p> <p>4.3 Water disinfection, Activated carbon filtration.</p> <p>4.4 Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree.</p> <p>4.5 Assessing the impact of HWTS.</p> <p>4.6 Government policies for HWTS.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Emerging drinking water treatment technologies</p> <p>1.1 New and Emerging Drinking Water Treatment Technologies- An overview.</p> <p>1.2 Nanotechnology, Acoustic nanotube technology.</p> <p>1.3 Photocatalytic water purification technology.</p> <p>1.4 Aquaporin Inside™ technology.</p> <p>1.5 Automatic Variable Filtration (AVF) technology.</p> <p>1.6 Sun Spring System, Desalination.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Vasileios A., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3 03943-3070. 2. Pannirselvam M., Shu Li.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3. 3. Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781. 4. Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1st edn. Bright Sun Publications. 5. Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2nd edn. Academic Press |

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| Reference Books | <ol style="list-style-type: none"> 1. Fujita K. and Mizushima T. (2021). Sustainable Development in India - Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976. 2. Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582. 3. Ahuja S. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955. 4. Saeid Eslamian, Faezeh Eslamian . (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications. 5. Buckley RG. (2 016) Environmental Microbiology 1st edn. CBS Publishing. |
| Web resources | <ol style="list-style-type: none"> 1. https://link.springer.com/book/10.1007/978-1-59745-278-6 2. https://apps.who.int/iris/handle/10665/206916?show=full 3. https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html 4. https://www.toftigers.org/best-practice/water-conservation-and-treatment/ 5. https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems/ |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Appraise issues of water scarcity, stress, and conflict on global population. |
| CO2 | Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation. |
| CO3 | Relate the connection between water quality and public health. |
| CO4 | Design and execute standard strategy for successful HWTS implementation. |
| CO5 | Cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | L | L | M | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | M | M | H |
| CO5 | H | H | M | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | M | M | L | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | H | M | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|--|-----------------|---------------------|----------------|--------------|--------------------|
| Title of the Course | SEC: ORGANIC FARMING AND BIOFERTILIZER TECHNOLOGY | | | | | |
| Paper No. | Skill Enhancement Course [SEC II] | | | | | |
| Category | Skill Enhancement | Year | II | Credits | 2 | Course Code |
| | | Semester | III | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | |
| | 2 | - | - | | 2 | |
| Objectives of the course | <ul style="list-style-type: none"> • Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture. • Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends. • Explain the various types of biofertilizer and the scope in its production. • Discuss about biofertilizer production and its field application, promoting economy. • Develop the skill to analyze the quality of packaging, storage, assess the shelf life and bioefficacy of biofertilizers. | | | | | |
| Course Outline | <p>UNIT I (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Organic farming</p> <p>Organic farming – Definition, relevance. Biological nutrient management - Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.</p> | | | | | |
| | <p>UNIT II (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Organic certification</p> <p>Certification and Schemes - Organic certification in brief. Integrated farming system- definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY.</p> | | | | | |
| | <p>UNIT III (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bacterial biofertilizers</p> <p>Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia.</p> | | | | | |

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| | <p>UNIT IV (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Cyanobacterial and fungal biofertilizers</p> <p>Cyanobacterial biofertilizers- Anabaena, Nostoc, Hapalosiphon and fungal biofertilizers- AM mycorrhiza and ectomycorrhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization.</p> |
| | <p>UNIT V (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Production technology</p> <p>Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Sharma A. K. (2001). Hand book of Organic Farming. Agrobios. 2. Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers. Ambika Book Agency. 3. Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4th Edition). Med Tech publisher. 4. Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. 5. Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers. |
| Reference Books | <ol style="list-style-type: none"> 1. Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1st Edition). Jain Brothers. 2. Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi. 3. Bansal M. (2019). Basics of Organic Farming. CBS Publisher. 4. Bhoopander G., Ram Prasad., (2019) Biofertilizer for sustainable agriculture and Environment, Springer 5. Niir Board., (2012). Biofertiliser and organic farming. (1st Edition). Daya publishers. |
| Web resources | <ol style="list-style-type: none"> 1. https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html 2. https://www.fao.org/organicag/oa-faq/oa-faq6/en/ 3. https://www.india.gov.in/topics/agriculture/organic-farming 4. https://agriculture.nagaland.gov.in/bio-fertilizer/ 5. https://www.ccd.ngo/sustainableagriculture.html |

| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Produce biofertilizers and distinguish between organic and conventional farming. |
| CO2 | Plan a Complete Farm Business including marketing, operation and financial outline. |
| CO3 | Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility. |
| CO4 | Develop integrated farming for sustainable agriculture. |
| CO5 | Promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per BIS standards |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | M | L | M | M | H |
| CO3 | H | M | L | M | M | H |
| CO4 | H | M | H | H | H | H |
| CO5 | H | L | M | L | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | H | H |
| CO2 | H | M | L | M | L | H |
| CO3 | H | M | L | M | L | H |
| CO4 | H | M | H | H | L | H |
| CO5 | H | L | M | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | FOOD AND DAIRY MICROBIOLOGY | | | | | | |
|------------------------------|--|----------|--------------|---------|-------|-------------|---------|
| Paper No. | Core Course XI | | | | | | |
| Category | Core | Year | II | Credits | 5 | Course Code | PCMBK24 |
| | | Semester | IV | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Discuss microorganisms involved in food spoilage. • Illustrate bacterial and nonbacterial food borne infections important in public health. • Familiarize various national and international aspects of food safety and quality assurance. • Elaborate on microbiology of milk, preservation techniques and production of dairy products. • Explain Dairy plant hygiene, quality control and waste disposal. | | | | | | |
| Course Outline | <p>UNIT I (18 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microorganisms of food and food preservation</p> <p>1.1 Microorganisms of food. 1.2 Scope of food Microbiology. 1.3 Contamination and spoilage of food –vegetables, fruits, eggs, poultry, fish, 1.4 Contamination of meat, meat products and canned foods. 1.5 Food Preservation - Temperature (low and high), drying, radiation. 1.6 Chemical preservation.</p> | | | | | | |
| | <p>UNIT II (18 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Food borne illness</p> <p>2.1 Food microbiology and public health. Food hazards. 2.2 Food infections - Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonella, Shigella. 2.3 Yersinia enterocolitica, Listeria monocytogenes and Campylobacter jejuni. 2.4 Nonbacterial food borne illness - Helminthes, nematodes, protozoa, 2.5 Toxigenic fungi. 2.6 Food borne virus.</p> | | | | | | |
| | <p>UNIT III (18 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Quality assurance of food</p> <p>3.1 Quality assurance of food – An overview. 3.2 International aspects of Quality and safety assessment of foods. 3.3 Microbiological quality standards for food. 3.4 Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. 3.5 Food adulteration 3.6 Common food additives.</p> | | | | | | |

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| | <p>UNIT IV (18 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Dairy Microbiology</p> <p>4.1 Introduction to Dairy microbiology – Milk production and hygiene.</p> <p>4.2 Microorganisms associated with milk. Microbial metabolites and their role in spoilages- souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour.</p> <p>4.3 Antimicrobial systems in raw milk.</p> <p>4.4 Microbiological grading of raw milk.</p> <p>4.5 Milk borne diseases and their control.</p> <p>4.6 Bacteriological aspects of milk processing – Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration.</p> |
| | <p>UNIT V (18 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Dairy products and disposal of dairy waste</p> <p>5.1 Composition and chemistry of cream, butter, ghee, ice cream, cheese, kefir, koumiss, rennin, condensed and dried milks, infant food.</p> <p>5.2 Spoilage of ghee and use of antioxidants. Chemistry of milk fermentation.</p> <p>5.3 Chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose, crystallization and its significance.</p> <p>5.4 Dairy plant hygiene and sanitation.</p> <p>5.5 Disposal of dairy waste.</p> <p>5.6 Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO standards.</p> |
| <p>Text Books</p> | <ol style="list-style-type: none"> 1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi. 2. Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education. 3. Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer. 4. Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4th Edition). American Society for Microbiology Press. 5. Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press. |
| <p>Reference Books</p> | <ol style="list-style-type: none"> 1. Robinson R. K. (2000). Dairy Microbiology 3rd edn, Elsevier Applied Science, London. 2. Adams M.R, and Moss M.D, (2005). Food Microbiology 4th edn, New Age International Pvt. Ltd., Publishers. 3. Banwarst. G.J. (2003). Basic Food Microbiology. 2nd edn, CBS Publishers and distributors. 4. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7th edn. Edward Arnold: London. |

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| | 5. Vijaya R K, (2004). Food Microbiology 1st edn. MJP Publishers, Chennai. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.fssai.gov.in 2. https://www.who.int/news-room/fact-sheets/detail/food-safety 3. https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines |

| CO | Course Outcomes |
|---|--|
| On completion of this course, students will be able to; | |
| CO1 | Utilize the knowledge on process of food contamination and spoilage to preserve food. |
| CO2 | Use the knowledge on food borne disease to protect public health. |
| CO3 | Familiarize various national and international aspects of food safety and quality assurance. |
| CO4 | Prepare dairy products and perform quality checks. |
| CO5 | Apply microbiological standards to milk and milk products. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | L | L | M | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | M | M | H |
| CO5 | H | H | M | H | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | M | L | H | M |
| CO2 | H | M | M | L | L | H |
| CO3 | H | H | M | H | L | H |
| CO4 | H | L | L | L | M | H |
| CO5 | H | H | M | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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|-------------------------------------|---|-----------------|---------------------|----------------|--------------|--------------------|----------------|
| Title of the Course | RESEARCH METHODOLOGY AND BIOSTATISTICS | | | | | | |
| Paper No. | Core Course XII | | | | | | |
| Category | Core | Year | II | Credits | 5 | Course Code | PCMBL24 |
| | | Semester | IV | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 6 | - | - | | 6 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Discuss the methods and techniques of data collection. • Explain sampling methods, write research reports and articles. • Discuss the basic concepts of Biostatistics. • Describe statistical software for analysis. • Explain the tests of significance. | | | | | | |
| Course Outline | <p>UNIT I (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Introduction to Research methodology</p> <p>1.1 Introduction to Research Methodology - Meaning and importance. Statement, Constraints. 1.2 Review of literature - Review and synopsis presentation. 1.3 Types of research, Research tools. 1.4 Methods and techniques of data collection. 1.5 Types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case /pilot study, methods). 1.6 Methods of secondary data collection.</p> | | | | | | |
| | <p>UNIT II (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Sampling distribution and Plagiarism</p> <p>2.1 Sampling and sampling distributions. 2.2 Sampling frame, importance of probability sampling, sampling - simple random, systematic, stratified random and cluster. 2.3 Variables - nominal, ordinal, discontinuous, continuous, derived. 2.4 Research process, designs and Report writing. 2.5 Types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, 2.6 Plagiarism and Self Plagiarism.</p> | | | | | | |
| | <p>UNIT III (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Introduction to Biostatistics</p> <p>3.1 Introduction to Biostatistics - Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. 3.2 Measures of central tendency: Mean, Median, Mode. 3.3 Measures of variability - Standard deviation, standard error, range, mean deviation and</p> | | | | | | |

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| | <p>coefficient of variation.</p> <p>3.4 Frequency table of single discrete variable, bubble plot, computation of mean, variance and standard Deviations.</p> <p>3.5 T test.</p> <p>3.6 correlation coefficient.</p> |
| | <p>UNIT IV (20 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Corelation and regression</p> <p>4.1 Correlation and regression - Positive, negative.</p> <p>4.2 Calculation of Karl-Pearsons co-efficient of correlation.</p> <p>4.3 Linear regression and multiple linear regression.</p> <p>4.4 ANOVA, one- and two-way classification.</p> <p>4.5 Calculation of an unknown variable using regression equation.</p> <p>4.6 Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error.</p> |
| | <p>UNIT V (15 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Probability and distributions</p> <p>5.1 Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems).</p> <p>5.2 Computer oriented statistical techniques.</p> <p>5.3 RSM: methods for process optimization set up CCD.</p> <p>5.4 Box Behnken, optimal RSM design,</p> <p>5.5 Regression models FDS curves, surface contours.</p> <p>5.6 Multi linear constraints and categoric factors to optimal design.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Sharma K. R. (2002) Research methodology. National Publishing House, New Delhi. 2. Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. (7th Edition). Jhon Wiley & sons Inc, New York. 3. Rao P. S. S. and Richard J. (2006). Introduction to Biostatistics & Research methods. Prentice-Hall, New Delhi. 4. Veerakumari L. (2015) Bioinstrumentation 1st edn. MJP Publishers. 5. Ahuja V.K. (2017) Laws Relating to Intellectual Property Rights. Lexis Nexis. |
| Reference Books | <ol style="list-style-type: none"> 1. Zar J. H. (2006). Biostatistical Analysis. (4th Edition). Pearson Education Inc. New Jersey. 2. Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics. Pearson Education Inc. New Jersey. 3. Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications. SAGE Publications, Inc., New Delhi. 4. Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4th edn. Wiley India Private Limited. 5. Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2nd Edition. New Age International Publishers. |

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| Web resources | <ol style="list-style-type: none"> 1. https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093 2. https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library/ 3. https://testbook.com/learn/maths-mean-median-mode/ 4. https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%20Correlation%20and%20Regression.pdf 5. https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf |
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| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Collect and present data suitable to the research design. |
| CO2 | Write research manuscripts and articles for journals. |
| CO3 | Recommend the utilization of biostatistics tools for analysis of biological data. |
| CO4 | Prove and justify hypothesis for particular research. |
| CO5 | Apply software tools for interpretation of biological data. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | H | L | L | H |
| CO2 | H | H | H | L | L | H |
| CO3 | H | H | H | L | L | H |
| CO4 | H | H | H | L | L | H |
| CO5 | H | H | H | L | L | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | H | H | H | L | H |
| CO3 | H | H | H | H | L | H |
| CO4 | H | H | H | H | L | H |
| CO5 | H | H | H | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE VI A: BIOENERGY | | | | | | |
|------------------------------|--|----------|--------------|---------|-------|-------------|----------------|
| Paper No. | Elective Course VI | | | | | | |
| Category | Elective (Discipline centric) | Year | II | Credits | 3 | Course Code | PEMBP24 |
| Semester | | IV | | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 4 | - | - | | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Acquire knowledge on bioenergy utilizing organic wastes for energy recovery. • Discuss methods and strategies of exploiting microbes for the production technology of biodiesel. • Describe resources and techniques for the production and estimation of ecofriendly biofuels and the extent of their use potentially. • Gain knowledge for executing biogas plant in communities. • Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Bioenergy</p> <p>1.1 Bioenergy – introduction. 1.2 Biomass Energy Resources. 1.3 Biomass conversion methods. 1.4 Microbes as bioresources for bioenergy products- Bacteria. 1.5 Microbes as bioresources for bioenergy products- Fungi and microalgae. 1.6 Bioprospecting of microbial strains for biofuel production.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biodiesel</p> <p>2.1 Biodiesel – Microbes and Biodiesel. 2.2 Production and feed stock. 2.3 Techniques of lipid extraction and conversion to biodiesel. 2.4 Biodiesel quality and its assessment. 2.5 Strategies of genetic engineering of organisms for biodiesel production. 2.6 Biodiesel production from single cell organisms (Cryptococcus, Cunninghamella, Mortierella).</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Alcoholic fuels from microbes</p> <p>3.1 Alcoholic Fuels from microorganisms: An overview 3.2 Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation.</p> | | | | | | |

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| | <p>3.3 Role of enzymes and their applications in ethanol production.</p> <p>3.4 Distillation and Quantification of ethanol.</p> <p>3.5 Production and Estimation of biobutanol, biomethanol.</p> <p>3.6 Production and Estimation of biopropanol and bioglycerol.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biogas production</p> <p>4.1 Biogas - Microbes and Biogas production.</p> <p>4.2 Biogas plants –design – construction.</p> <p>4.3 Biogas plant - types.</p> <p>4.4 Biogas Bottling Technology and Development in India.</p> <p>4.5 Biogas appliances – burner, luminaries and power generation – effect on engine performance.</p> <p>4.6 Application of Biogas slurry in agriculture.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biohydrogen production</p> <p>5.1 Biohydrogen– Production from bacteria and algae.</p> <p>5.2 Commercialized microalgae (Spirulina, Dunaliella) and their production.</p> <p>5.3 Commercialized microalgae (Hematococcus and Chlorella) and their production.</p> <p>5.4 Economics of microalgae production.</p> <p>5.5 Cultivation of seaweeds.</p> <p>5.6 Microbial fuel cells.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1st Edition). Academic Press Editor. 2. Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing. 3. Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1st Edition). Springer Cham. 4. Caye M. Drapcho, Tery H. Walker (2018) Biofuels Engineering Process Technology. McGraw Hill. 5. Teri. (2020) Bio energy Powering the Future. Pearson Longman Publications. |
| Reference Books | <ol style="list-style-type: none"> 1. Konur O. (2018). Bioenergy and Biofuels. (1st Edition). CRC Press. 2. Lee J. W. (2012). Advanced Biofuels and Bioproducts. (13th Edition), Springer. 3. Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing. 4. Pradeep Chaturvedi. (1995). Bioenergy Resources. Concept Publishing Company. 5. Lee S. (2018). Biofuel and Bioenergy. Taylor and Francis. |

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| Web resources | <ol style="list-style-type: none"> 1. https://www.elsevier.com Biofuels and Bioenergy 2. https://www.sciencedirect.com › book › bioenergy 3. https://www.un.org/en/climatechange/ 4. https://www.energy.gov/eere/bioenergy/bioenergy-basics 5. https://www.iea.org/fuels-and-technologies/bioenergy |
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| CO | Course Outcomes |
|---|---|
| On completion of this course, students will be able to; | |
| CO1 | Evaluate the various aspects of biomass production and their implementation. |
| CO2 | Design and construct a biodiesel plant. |
| CO3 | Carry out the process of fermentation for bio – alcohol fuels. |
| CO4 | Identify the nature of biogas as a biofuel and their technologies and applications. |
| CO5 | Design, execute and extract biohydrogen from algae. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | M | M | H |
| CO2 | H | H | H | L | L | M |
| CO3 | H | M | M | H | L | M |
| CO4 | H | M | H | H | M | M |
| CO5 | H | H | M | M | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | H | H | H | L | H |
| CO2 | H | M | H | M | L | H |
| CO3 | H | M | H | M | L | H |
| CO4 | H | M | H | M | L | H |
| CO5 | H | H | H | H | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

| Title of the Course | ELECTIVE VI B: MARINE MICROBIOLOGY | | | | | | |
|------------------------------|--|----------|--------------|---------|-------|-------------|----------------|
| Paper No. | Elective Course VI | | | | | | |
| Category | Elective (Discipline centric) | Year | II | Credits | 3 | Course Code | PEMBQ24 |
| | | Semester | IV | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 4 | - | - | | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans. • Discuss the metabolic diversity of marine microorganisms and their interrelationships. • Explain the survival of microorganisms in extreme environments. • Illustrate pathogens and contaminants in sea foods. • Describe the applications of marine biotechnological products and their future role in a rapidly changing planet. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Marine microbial environment</p> <p>1.1 Marine microbial environment - Benthic & littoral zone. 1.2 Salt pan, mangroves and 1.3 Estuarine microbes. 1.4 Microbial loop. 1.5 Marine microbial communities – Bacteria, fungi, protozoa. 1.6 Microbial interactions – Endosymbionts and Ectosymbionts.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Dynamics of Marine microbes</p> <p>2.1 Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming. 2.2 Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization. 2.3 Phosphorus cycle. 2.4 Decomposition of organic matter. 2.5 Biobleaching 2.6 Biodeterioration of natural and synthetic materials.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Extremophiles</p> <p>3.1 Marine extremophiles: Mechanism of survival at extreme environments. 3.2 Adaptive mechanisms in thermophilic and hyperthermophilic microorganisms. 3.3 Alkalophilic and psychrophilic microorganisms.</p> | | | | | | |

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| | <p>3.4 Osmophilic, barophilic microbes.</p> <p>3.5 Halophiles and its significance.</p> <p>3.6 Importance in biotechnology.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Marine microbial diseases</p> <p>4.1 Marine Microbial Diseases: an overview.</p> <p>4.2 Aqua culture pathogens & Water borne pathogens.</p> <p>4.3 Aeromonas, Vibrio, Salmonella, Pseudomonas.</p> <p>4.4 Leptospira, Corynebacteria.</p> <p>4.5 Viral diseases.</p> <p>4.6 Rapid diagnosis of contamination in sea foods and aquaculture products.</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Marine Microbial Biotechnology</p> <p>5.1 Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products.</p> <p>5.2 Enzymes, and Antibiotics.</p> <p>5.3 Organic acids and Toxins.</p> <p>5.4 Biosurfactants and Pigments.</p> <p>5.5 Sea food preservation methods.</p> <p>5.6 Probiotic bacteria and their importance in aquaculture.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3rd Edition). CRC Press. ISBN:9780367183561. 2. Bhakuni, D.S. and Rawat D. S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5. 3. Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860. 4. Nybakken, J.W. (2001). Marine Biology. (5th Edition). Benjamin Cummings. ISBN:0321030761. 5. Veena. (2003) Understanding marine biology. Discovery Publishing. |
| Reference Books | <ol style="list-style-type: none"> 1. Maier R. M., Pepper I. L. and Gerba C. P. (2006). Environmental Microbiology. (2nd Edition). Academic Press. ISBN:978-0-12-370519-8. 2. Belkin S. and Colwell R. R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4. 3. Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540 69357-4. 4. Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7. 5. Kim S. K. (2019). Essentials of Marine Biotechnology. Springer. |

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| Web resources | <ol style="list-style-type: none"> 1. https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1 2. https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products 3. http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf 4. https://link.springer.com/book/10.1007/b102184 5. https://www.wiley.com/enbs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187 |
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| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Apply the knowledge on marine microbial communities and their interactions. |
| CO2 | Illustrate the role of marine microorganisms in biogeochemical cycles. |
| CO3 | Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments. |
| CO4 | Identify the diseases affecting marine organisms and its diagnosis. |
| CO5 | Evaluate the marine microorganisms as a resource for novel microbial products. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|--------|------|------|------|------|------|------|
| CO1 | H | H | M | M | L | M |
| CO2 | H | H | H | L | L | M |
| CO3 | H | M | M | H | H | M |
| CO4 | H | M | H | H | H | M |
| CO5 | H | L | M | M | M | M |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-------|-----|-----|-----|-----|-----|-----|
| CO1 | H | H | H | H | L | L |
| CO2 | H | M | H | M | L | L |
| CO3 | H | M | H | H | L | L |
| CO4 | H | M | H | M | L | L |
| CO5 | H | H | H | H | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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| Title of the Course | ELECTIVE VI C: LIFE SCIENCES FOR COMPETITIVE EXAMINATIONS | | | | | | |
| Paper No. | Elective Course VI | | | | | | |
| Category | Elective (Discipline centric) | Year | II | Credits | 3 | Course Code | PEMBR24 |
| | | Semester | IV | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | | Total | | |
| | 4 | - | - | | 4 | | |
| Objectives of the course | <ul style="list-style-type: none"> • Impart knowledge on structure, metabolism and function of biomolecules. • Understand the importance of inheritance biology. • Discuss in-depth about the different types of ecosystems and their importance. • Outline the major drivers in biodiversity and various conservation approaches. • Introduce basic concepts of evolution and biological clock. | | | | | | |
| Course Outline | <p>UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Biomolecules</p> <p>1.1 Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).</p> <p>1.2 Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA).</p> <p>1.3 Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins.</p> <p>1.4 Structure of atoms, molecules and chemical bonds.</p> <p>1.5 Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).</p> <p>1.6 Bioenergetics.</p> | | | | | | |
| | <p>UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Cellular Organisation</p> <p>2.1 Cellular Organisation - Cell division and cell cycle.</p> <p>2.2 Membrane structure and function.</p> <p>2.3 Organization of genes and chromosomes</p> <p>2.4 Structural organization and function of intracellular organelles</p> <p>2.5 DNA replication, repair and recombination.</p> <p>2.6 Protein synthesis and processing.</p> | | | | | | |
| | <p>UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Inheritance Biology</p> <p>3.1 Inheritance Biology, Mendelian principles- Dominance, segregation, independent assortment, Linkage.</p> <p>3.2 Gene mapping.</p> <p>3.3 Karyotyping.</p> | | | | | | |

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| | <p>3.4 Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes.</p> <p>3.5 Maternal inheritance.</p> <p>3.6 Human genetics-Pedigree analysis, lod score for linkage testing.karyotypes, genetic disorders.</p> |
| | <p>UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Ecology</p> <p>4.1 Ecology- Habitat and Niche, biotic and abiotic interactions, Biome- biogeographical zones of India.</p> <p>4.2 Ecological Succession, Population Ecology- Characteristics of a population; population growth curves.</p> <p>4.3 Environmental pollution-global environmental change.</p> <p>4.4 Biodiversity: status, monitoring and documentation; major drivers of biodiversity change.</p> <p>4.5 Biodiversity Management approaches.</p> <p>4.6 Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).</p> |
| | <p>UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Evolution and Behaviour</p> <p>5.1 Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences.</p> <p>5.2 Hardy Weinberg's Law.</p> <p>5.3 Speciation; Allopatricity and Sympatricity.</p> <p>5.4 Adaptive radiation and Convergent evolution; Sexual selection; Co evolution.</p> <p>5.5 Altruism, Biological clocks, Migration and Parental care.</p> <p>5.6 Molecular Evolution- Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5th Edition). W.H. Freeman and Company. 2. Chapman J. L. (1998). Ecology: Principles and Applications. (2nd Edition). Cambridge University Press. 3. Krishnamurthy V. K. (2003). Textbook of Biodiversity. Science Publishers. 4. Rogers A. L. (2011). Evidence of Evolution. University of Chicago Press. Chicago. 5. Stites D.P.,Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, Prentice-Hall Inc. |
| Reference Books | <ol style="list-style-type: none"> 1. Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer. 2. Verma P. S. and Agarwal V. K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication. 3. Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black well Publishing Company. 4. Boyer R.F. (2002) Modern Experimental Biochemistry. (3rd Edition). Pearson Education. |

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| | 5. Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. (8th Edition) Cambridge University Press. |
| Web resources | <ol style="list-style-type: none"> 1. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_ 2. https://www.livescience.com/474-controversy-evolution-works.html. 3. https://www.examrace.com/Study-Material/Life-Sciences/ 4. https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts 5. https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html |

| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Define, classify and assess the structure, biological functions and interactions of Biomolecules. |
| CO2 | Validate the knowledge of collective and progressive notions of cellular organization. |
| CO3 | Assess and describe the importance of inheritance biology. |
| CO4 | Establish acquaintance and understanding of ecology & Biodiversity in a broader sense. |
| CO5 | Understand the processes of evolution, relate with natural selection, adaptation and speciation. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|--------|------|------|------|------|------|------|
| CO1 | H | H | M | M | M | H |
| CO2 | H | H | M | L | L | H |
| CO3 | H | M | L | H | M | H |
| CO4 | H | M | L | H | M | H |
| CO5 | H | H | M | M | H | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-------|-----|-----|-----|-----|-----|-----|
| CO1 | H | H | H | L | H | H |
| CO2 | H | H | H | M | L | H |
| CO3 | H | H | H | L | M | H |
| CO4 | H | M | H | L | M | H |
| CO5 | H | H | H | L | H | H |

(HIGH - 3, MODERATE - 2, LOW - 1)

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| Title of the Course | MICROBIAL QUALITY CONTROL AND TESTING | | | | | | |
| Paper No. | Skill Enhancement Course [SEC III] | | | | | | |
| Category | Professional competency skill | Year | II | Credits | 2 | Course Code | PPMB24 |
| | | Semester | III | | | | |
| Instructional hours per week | Lecture | Tutorial | Lab Practice | Total | | | |
| | 3 | - | - | 3 | | | |
| Objectives of the course | <ul style="list-style-type: none"> • Explain various microbiological quality standards for food, water and air regulatory practices and policies. • Discuss collection, processing and preservation of water samples from industries in different areas. • Enumeration and isolation of microorganism from the water samples. • Enumeration and isolation of microorganism from the air samples. • Gain knowledge on sterility testing of different components in industries and quality control techniques. | | | | | | |
| Course Outline | <p>UNIT I (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Quality control and Quality assurance</p> <p>Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.</p> | | | | | | |
| | <p>UNIT II (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Waste Water Microbiology</p> <p>Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies.</p> | | | | | | |
| | <p>UNIT III (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microbiological analysis of water</p> <p>Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens - Precipitation, chemical disinfection, filtration, high temperature, UV light.</p> | | | | | | |

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| | <p>UNIT IV (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Microflora of Air</p> <p>Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration.</p> |
| | <p>UNIT V (6 hours) (K1, K2, K3, K4, K5 & K6)</p> <p>Quality control of food and Pharma products</p> <p>Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.</p> |
| Text Books | <ol style="list-style-type: none"> 1. Aneja R. P., Mathur B.N., Chandan R. C. and Banerjee, A. K. (2002). Experiments in Microbiology. 2. Adams M. R. and Moss M. O. (2006). Food Microbiology. (2nd Edition). Royal Society of Chemistry. 3. Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand. 4. Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi. 5. Rosamund M. Baird., Norman A. (2019). Handbook of Microbiological quality control in Pharmaceuticals and Medical Devices. CRC Press. |
| Reference Books | <ol style="list-style-type: none"> 1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). Taylor & Francis. 2. Sundararaj T. (2003). Microbiology Laboratory Manual. (2nd Edition). Published by A. Sundararaj 3. Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics & Toiletries. by Sally F. Bloomfield 4. Amitava Mitra. (2015). Fundamentals of Quality control and Improvement. (3rd Edition). Wiley Publications . 5. David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing. Wiley Publishers. |
| Web resources | <ol style="list-style-type: none"> 1. https://www.researchgate.net/publication/320730681 2. https://www.fssai.gov.in 3. https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc 4. https://www.who.int/news-room/fact-sheets/detail/food-safety |

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| | 5. https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines |
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| CO | Course Outcomes |
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| On completion of this course, students will be able to; | |
| CO1 | Apply knowledge in quality analysis techniques suitable for industries. |
| CO2 | Perform water managements, water harvesting and treat sewage, water pollutions and remedies. |
| CO3 | Detect portability of water by testing water quality. |
| CO4 | Impart knowledge on bioaerosols, impact and prevention. |
| CO5 | Apply quality control techniques for food and pharma products. |

| CO/PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CO1 | H | H | M | H | L | H |
| CO2 | H | H | H | L | M | H |
| CO3 | H | H | M | M | L | H |
| CO4 | L | H | H | H | L | H |
| CO5 | L | H | M | L | M | H |

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|--------------|------------|------------|------------|------------|------------|------------|
| CO1 | H | M | M | H | L | H |
| CO2 | H | H | H | L | L | H |
| CO3 | H | M | M | M | L | H |
| CO4 | H | M | H | H | L | H |
| CO5 | H | M | M | L | L | H |

(HIGH - 3, MODERATE - 2, LOW - 1)