DEPARTMENT PROFILE

The Department of Microbiology was established in the year 1994 with UG course. The Post Graduate Microbiology course was started in the year 2000. The Department has produced 29 UG batches and 16 PG batches. Ever since its inception, the Department has been constantly concentrating to stay updated with the latest developments. The Department has well equipped laboratory and library to cater the requirements of the syllabi. All the graduates and postgraduates of the Department have been well placed in the various fields of Microbiology. The Postgraduate Department has 6 faculty members who are eminent scholars and have wide knowledge in the field.

VISION

- To be a focal point of brilliance in higher education that emphasizes pioneering education, knowledge on research and development in the field of microbiology.

MISSION

- To afford eminent edification in microbiology programmed to enrich the academic foundation and preparation of students for life in an intricate dynamic technological world.
- To generate and propagate awareness through interdisciplinary research in the field of Microbiology

Signature of the Chairman

DISTRIBUTION OF CREDITS

S. No.	PART	NO.OF PAPERS	CREDITS
1.	CORE	12	56
2.	ELECTIVE	7	21
3.	SUPPORTIVE (Skill)	4	8
4.	INTERNSHIP	1	2
5.	PROJECT	1	7
	TOTAL	25 Papers	94 CREDITS

SEMESTER–WISE CREDITS

I – SEMESTER	–	22
II – SEMESTER	–	22
III – SEMESTER	–	24
IV – SEMESTER	–	26
TOTAL		94

Signature of the Chairman

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The Programme Educational Objectives of the **B.Sc. in Microbiology Programme** at Sourashtra College, Madurai are given below and are numbered from PEO1 to PEO5.

PEO1	To provide in-depth knowledge about core areas of biosciences such as biotechnology, biochemistry and microbiology.
PEO2	To make students competent in the field of biosciences and allied areas by providing them hands on experience in basic tools and techniques
PEO3	To instil the ability for research and entrepreneurship in the students along with strong ethics and communication skills.
PEO4	To inculcate, facilitate, motivate and promote knowledge technical skills in core areas of biological sciences including advanced tools and techniques like genomics, proteomics and transcriptomics to young aspirants and to equip and motivate the students to pursue higher education and research in reputed institutes at national and international level in the field Science
PEO5	To develop trained human resource in the field of advanced translational research and to develop graduates with a strong professional ethics and moral duties that will positively affect their profession, community, society and Nation at large.

POSTGRADUATE (PG) PROGRAMME OUTCOMES (POs)

Postgraduate (M.A., **M.Sc.,** M.Com., M.C.A., M.B.A., etc.,) is a 2–year degree Programme with 4 semesters consisting the following Programme Outcomes (POs) under various criteria including critical thinking, problem solving, effective communication, societal/ citizenship/ ethical credibility, sustainable growth and employable abilities.

PO 1	**Critical Thinking**: Intellectual exploration of knowledge towards actions in clear and rational manner by understanding the logical connections between ideas and decisions.
PO 2	**Problem Solving**: Understanding the task/ problem followed by planning and narrow execution strategy that effectively provides the solution.
PO 3	**Effective Communication**: Knowledge dissemination by oral and verbal mechanisms to the various components of our society.
PO 4	**Societal/ Citizenship/ Ethical Credibility**: Realization of various value systems/ moral dimensions and demonstrate the empathetic social concern as well as equity in all the decisions, executions and actions.
PO 5	**Environmental Concern and Sustainable Growth**: Understanding the emerging environmental challenges and provide the possible contribution in sustainable development that integrates environment, economy and employment.
PO 6	**Skill Development and Employable Abilities**: Adequate training in relevant skill sector and creating employable abilities among the post graduates.

PROGRAMME SPECIFIC OUTCOMES (PSOs) – PG

On completion of **M.Sc. Microbiology** Programme, the students are expected to

PSO –1	**Placement** Prepare the students in varied disciplines like agriculture, industry - medical, pharma, dairy, hotel, food and food processing, immunological, cosmetics, vermitechnology and water treatment for effective and respectful placement.
PSO – 2	**Entrepreneurship** To create effective entrepreneur by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.
PSO – 3	**Research and Development** Design and implement HR systems that comply with good laboratory, practices, following ethical values, leading the organization towards growth and development. .
PSO – 4	**Contribution to Society** To contribute to the development of society and produce microbiological products, by collaborating with stake holders, related to the betterment of environment and mankind at the national and global level.

M.Sc. MICROBIOLOGY – I YEAR
COURSE STRUCTURE – I SEMESTER

S. No.	Sub. Code	Subject Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC11	**Core – 1:** General Microbiology and Microbial Diversity	6	3	25	75	100	5
2.	23PMBC12	**Core – 2:** Microbial Physiology	6	3	25	75	100	5
3.	23PMBCP1	**Core – 3:** Practical – I – General Microbiology, Microbial Diversity and Microbial Physiology	6	6	40	60	100	4
4.	**Elective–1:**		5	3	25	75	100	3
	23PMBE11	Forensic Science						
	23PMBE12	Nanobiotechnology						
	23PMBE13	Microalgal Technology						
5.	**Elective – 2:**		5	3	25	75	100	3
	23PMBE14	Bioinstrumentation						
	23PMBE15	Herbal Technology and Cosmetic Microbiology						
	23PMBE16	Essentials of Laboratory Management and Biosafety						
6.	23PMBS11	**Skill Enhancement Course – 1:** Entrepreneurship in Biobusiness	2	3	25	75	100	2
		TOTAL	30					22

Signature of the Chairman

COURSE STRUCTURE – II SEMESTER

S. No.	Sub. Code	Subject Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC21	**Core – 4:** Medical Bacteriology and Mycology	6	3	25	75	100	5
2.	23PMBC22	**Core – 5:** Medical Virology and Parasitology	6	3	25	75	100	5
3.	23PMBCP2	**Core – 6:** Practical – II – Medical Microbiology	6	6	40	60	100	4
4.		**Elective – 3:**	5	3	25	75	100	3
	23PMBE21	Epidemiology						
	23PMBE22	Clinical and Diagnostic Microbiology						
	23PMBE23	Bioremediation						
5.		**Elective – 4:**	5	3	25	75	100	3
	23PMBE24	Bioinformatics						
	23PMBE25	Biosafety, Bioethics and IPR						
	23PMBE26	Clinical Research and Clinical Trials						
6.	23PMBS21	**Skill Enhancement Course – 2:** Vermitechnology	2	3	25	75	100	2
		TOTAL	30					22

COURSE STRUCTURE – III SEMESTER

S. No.	Sub. Code	Subject Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.		**Core – 7:** Immunology and Microbial Genetics	6	3	25	75	100	5
2.		**Core – 8:** Molecular Biology and Recombinant DNA Technology	6	3	25	75	100	5
3.		**Core – 9:** Practical – III – Immunology, Microbial Genetics and Molecular Biology	6	6	40	60	100	4
4.		**Elective–5:**	5	3	25	75	100	3
		Soil Microbiology and Microbial Ecology						
		Microbial Toxicology						
		Water Conservation and Water Treatment						
5.		**Elective – 6:**	5	3	25	75	100	3
		Fermentation Technology and Pharmaceutical Microbiology						
6.		**Skill Enhancement Course-2:** Organic Farming and Biofertiliser Technology	2	3	25	75	100	2
7.		**Extension Activity:** Internship/Industrial Activity	-					2
		TOTAL	30					24

COURSE STRUCTURE – IV SEMESTER

S. No.	Sub. Code	Subject Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.		**Core – 10:** Food and Environmental Microbiology	6	3	25	75	100	5
2.		**Core – 11:** Research Methodology and Biostatistics.	6	3	25	75	100	5
3.		**Core – 12:** Practical – IV – Applied Microbiology	6	6	40	60	100	4
4.		**Elective – 7:**	5	3	25	75	100	3
		Bioenergy						
		Marine Microbiology						
		Life Science for Competitive Examinations						
5.		**Skill Enhancement Course-3:** Microbial Quality Control and Testing	2	3	25	75	100	2
6.		Project with Viva Voce	5	4	40	60	100	7
		TOTAL	30					26

COURSE STRUCTURE – I SEMESTER

S. No.	Sub. Code	Subject Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1.	23PMBC11	**Core – 1:** General Microbiology and Microbial Diversity	6	3	25	75	100	5
2.	23PMBC12	**Core – 2:** Microbial Physiology	6	3	25	75	100	5
3.	23PMBCP1	**Core – 3:** Practical – I – General Microbiology, Microbial Diversity and Microbial Physiology	6	6	40	60	100	4
4.		**Elective–1:**	5	3	25	75	100	3
	23PMBE11	Forensic Science						
	23PMBE12	Nanobiotechnology						
	23PMBE13	Microalgal Technology						
5.		**Elective – 2:**	5	3	25	75	100	3
	23PMBE14	Bioinstrumentation						
	23PMBE15	Herbal Technology and Cosmetic Microbiology						
	23PMBE16	Essentials of Laboratory Management and Biosafety						
6.	23PMBS11	**Skill Enhancement Course-1:** Entrepreneurship in Biobusiness	2	3	25	75	100	2
		TOTAL	30					22

CA – Class Assessment (Internal)

SE – Summative Examination

T – Theory

P – Practical

Signature of the Chairman

SOURASHTRA COLLEGE, MADURAI – 625004

(An Autonomous Institution Re-accredited with 'B+' grade by NAAC)

M.Sc. MICROBIOLOGY – SYLLABUS

(Under CBCS based on OBE) (with effect from 2023 – 2024)

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC11	GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY	CORE – 1	6	–	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

This course covers a detailed analysis of the diversity of microorganisms, bacterial cell structure and function, microbial growth and metabolism, and the ways to control their growth by physical and chemical means.

COURSE OBJECTIVES:

- To acquire knowledge on the principles of different types of microscopes and their applications.
- To explain various pure culture techniques and discuss sterilization methods.
- To exemplify, isolate and cultivate microalgae from diverse environmental sources.
- To compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria.
- To discuss the importance and conservation of microbial diversity.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes.	Upto K6
CO 2	create aseptic conditions by following good laboratory practices.	Upto K6
CO 3	identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on itseconomic importance.	Upto K6
CO 4	differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.	Upto K6
CO 5	categorize and cultivate a variety of extremophiles following standard protocols for industrial applications.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

Signature of the Chairman

GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY

UNIT – I:

History and Scope of Microbiology. Microscopy – Principles and applications. Types of Microscopes – Bright field, Dark–field, Phase–contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM& TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.

UNIT – II:

Microbial techniques – Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems – Pure cultures techniques – Cultivation of Anaerobic organisms.

Maintenance and preservation of pure cultures. Culture collection centres – National and International.

UNIT – III:

Algae – Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large–scale cultivation. Life cycle – *Chlamydomonas*, *Volvox Spirogyra* (Green algae), *Nostoc* (Cyanobacteria) *Ectocarpus, Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae).

UNIT – IV:

Bacterial Structure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi – Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition – Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.

UNIT – V:

Biodiversity – Introduction to microbial biodiversity – Thermophiles – Classification, Thermophilic Archaebacteria and its applications. Methanogens – Classification, Habitats, applications. Alkaliphiles and Acidophiles – Classification, discovery basin, its cell wall and membrane. Barophiles – Classification and its applications. Halophiles – Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes. Microbial stress response – Osmoadaptation / halotolerance – Applications of halophiles.

TEXT BOOKS:

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.

REFERENCES BOOKS:

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***. Elseiver 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.

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2
CO2	3	2	2	2
CO3	3	3	3	2
CO4	3	2	2	3
CO5	3	3	2	2

3. Advanced Application 2. Intermediate Development 1. Introductory Level

Signature of the Chairman

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC12	MICROBIAL PHYSIOLOGY	CORE – 2	6	–	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

It is an intensive course with the goal of integrating biochemistry and genetics to enhance the understanding of the microbial cell and the robust and diverse nature of life.

COURSE OBJECTIVES:

- To illustrate Bacterial nutrition and their utilization.
- To discuss cultivation methods and factors related to microbial growth.
- To demonstrate concepts of microbial metabolism.
- To impart the fundamentals and importance of biosynthetic pathways.
- To discuss the methods involved in Photosynthesis.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apply knowledge about nutritional requirement, modes of nutrient transport in microorganisms to various disciplines ofMicrobiology.	Upto K6
CO 2	analyse microbial growth, factors influencing growth and its measurement techniques for applications in various industries.	Upto K6
CO 3	compare various metabolic pathways and discuss the properties and functions of enzymes.	Upto K6
CO 4	apply anaerobic respiration and biosynthetic pathways to enhance/control microbial growth.	Upto K6
CO 5	assimilate methods involved in microbial photosynthesis and bioluminescence.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

Signature of the Chairman

MICROBIAL PHYSIOLOGY

UNIT – I:

Nutrition – Nutritional requirements and types in bacteria – Phototrophs, Chemotrophs, Autotrophs and Heterotrophs. Nutrient transport mechanisms– Passive diffusion, Facilitated diffusion, Active transport, Group translocation
and Specific transport system.

UNIT – II:

Microbial growth – Growth curve and Measurement of Growth – Cell Number and Cell Mass and metabolic activity. Batch, Continuous, Synchronousand Asynchronous cultures, Factors affecting growth.

UNIT – III:

Enzymes – properties, functions and regulation. Basic concepts of metabolism, Oxidation – reduction reactions, Energy generation by anaerobic metabolism – Glycolysis, Pentose Phosphate pathway, ED pathway, Fermentation. Energy generation by Aerobic metabolism – TCA cycle, Glycoxylate pathway and Electron Transportchain, Mechanism of ATP synthesis – Chemiosmosis, Pasteur effect. Metabolism of lipids–β oxidation.

UNIT – IV:

Anaerobic Respiration. Nitrogen, Sulphur, Iron and Hydrogen Oxidation. Methanogenesis.
Biosynthesis – Gluconeogenesis, Peptidoglycan synthesis,Amino acids, Purines, Pyrimidines Fattyacids, Triglycerides, Phospholipids and Sterols.

UNIT – V:

Photosynthesis – process, antenna of light–harvestingpigments, Photochemical reaction centers, Photosynthetic Electron Transport Chain–Cyclicand Non–cyclic. Oxygenic and Anoxygenic Photosynthesis. Calvin–Benson cycle. Bioluminescence – Process andapplication.

TEXT BOOKS:

1. Stanier R.Y., Ingraham, J.L., Wheelis, M.L and Painter, P.R. (2010). ***General Microbiology***. 5th Edn. Macmilan Education Ltd. London.
2. Prescott. L.M., Harley. J.P., Klein. D.A. (1993). ***Microbiology***. 2nd Edn. Wm. C.Brown publishers, Dubugue.
3. Moat, A.G. and Foster, J.W. (2003). ***Microbial Physiology***.4th Edn. John Wiley and Sons, New York.
4. Doelle, H.W. (1975) ***Bacterial Metabolism***, 2nd Edn. Academic Press, London.
5. Caldwell, D.R (2000) ***Microbial Physiology and Metabolism***, 2nd Edn. Star Publishing, Belmont, California.

Signature of the Chairman

REFERENCE BOOKS:

1. Salle. A.J. (1992). ***Fundamental Principles of Bacteriology***. 7th edn. McGraw Hill Inc.New York.
2. Madigan, M.T., Martinko, J.M., & ParkerJ. (2000). ***Brock Biology of Microorganisms***. 9th Edn. Prentice Hall International, Inc, London.
3. Ingraham, J.L., & Ingraham, C.A. (2000). ***Introduction to Microbiology***. 2nd Edn. Brook /Cole. Singapore.
4. Gottschalk, G. (1986). ***Bacterial Metabolism***.2nd Edn. Springer–Verlag, NewYork.
5. Rose, A.H. (1976). ***An Introduction to Microbial Physiology***. 3rd Edn. Plenum, New York.

DIGITAL TOOLS:

1. https://courses.lumenlearning.com/boundless–microbiology/chapter/microbial– nutrition/
2. https://www.lamission.edu/lifesciences/lecturenote/mic20/Chap06Growth.pdf
3. https://www.tandfonline.com/doi/abs/10.3109/07388558409082583?journalCo de=ibty20
4. https://wew.sciencedirect.com/topics/neuroscience/microbial–respiration.
5. https://www.britannica.com/science/photosynthesis.

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**2**
CO2	**2**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**2**
CO4	**3**	**2**	**2**	**3**
CO5	**3**	**3**	**3**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

Signature of the Chairman

SOURASHTRA COLLEGE, MADURAI – 625004

(An Autonomous Institution Re-accredited with 'B+' grade by NAAC)

M.Sc. MICROBIOLOGY – SYLLABUS

(Under CBCS based on OBE) (with effect from 2023 – 2024)

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBCP1	PRACTICAL I – GENERAL MICROBIOLOGY, MICROBIALDIVERSITY AND MICROBIAL PHYSIOLOGY	CORE – 3 PRACTICAL – I	–	6	4

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	40	60	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	

COURSE DESCRIPTION:

This course provides a practical knowledge on General Microbiology, MicrobialDiversity and Microbial Physiology

COURSE OBJECTIVES:

- To provide knowledge on the fundamentals, handling and applications of microscopy,
- To provide fundamental skills in sterilization methods. Identify microbes by different staining methods.
- To help the students prepare media for bacterial growth. Analyze microbial enzymes.
- To help the students perform plating techniques and methods involved in microbial preservation.
- To help the students measure bacterial growth, identify optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apply microscopic techniques and staining methods in theidentification and differentiation of microbes.	Upto K6
CO 2	apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth.	Upto K6
CO3	prepare media for bacterial growth. Analyze microbial enzymes.	Upto K6
CO4	pertain plating techniques and methods involved in microbial preservation.	Upto K6
CO5	analyze microbial growth, optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

Signature of the Chairman

GENERAL MICROBIOLOGY, MICROBIALDIVERSITY AND MICROBIAL PHYSIOLOGY

UNIT – I:

Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Micrometry. Dark field microscopy – Motility of Spirochetes. Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration. Quality control check for each method.

UNIT – II:

Staining techniques – Simple staining, Gram's staining, Acidfast staining,Meta chromatic granule staining, Spore, Capsule, Flagella.

UNIT – III:

Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media. Preparation of Biochemical test media, media to demonstrate enzymatic activities.

UNIT – IV:

Purification and maintenance of microbes. Streak plate, pourplate, and slide culture technique. Aseptic transfer. Direct counts – Total cell count, Turbidometry. Viable count – pour plate, spread plate.

UNIT – V:

Bacterial growth curve. Effect of physical and chemical factors on growth. Anaerobic culture methods.

TEXT BOOKS:

1. Dubey R.C. and Maheshwari D. K. (2010). ***Practical Microbiology***. S. Chand.
2. Cappuccimo, 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. Moat, A.G. Foster, J.W. and Spector, M. P (2002) ***Microbial Physiology***, 4th Edn. Wiley – Liss, New York.
5. Dawes, I. W. and Sutherland, I. W (1992) ***Microbial Physiology***, 2nd Edn. Black–well Scientific Publications, London.

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. Stanier R.Y., Ingraham, J.L., Wheelis, M.L and Painter, P.R. (2010). ***GeneralMicrobiology***. 5th Edn. Macmilan education Ltd. London.
3. Prescott. L.M., Harley. J.P., Klein. D.A. (1993). ***Microbiology***. 2nd edn. Wm. C. Brownpublishers, Dubugue.
4. Gottschalk, G. (1986***). Bacterial Metabolism***.2nd Edn. Springer–Verlag, New York.
5. Rose, A.H. (1976). An Introduction to ***Microbial Physiology***. 3rd Edn. Plenum, New York.

DIGITAL TOOLS:

1. http://textbookofbacteriology.net/
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/
3. http://sciencenetlinks.com/tools/microbeworld
4. https://www.microbes.info/
5. https://www.asmscience.org/VisualLibrary

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	2
CO2	3	3	2	2
CO3	2	3	3	2
CO4	2	3	2	3
CO5	3	3	2	2

3. Advanced Application 2. Intermediate Development 1. Introductory Level

Signature of the Chairman

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE11	FORENSIC SCIENCE	ELECTIVE 1 – I	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	✓

COURSE DESCRIPTION:

This course helps the students to analyse the various places of crimes, the objects found in the scene. The students are taught to make interpretations and conclusions. Forensic science plays a crucial role in solving crime by finding evidence from the crime spot.

COURSE OBJECTIVES:

- To understand the Scope, need and learn the tools and techniques in forensic science.
- To help the students comprehend organizational setup of a forensic science laboratory.
- To help the students identify and Examine body fluids for identification.
- To help the students extract DNA from blood samples for investigation.
- To help the students recognize medico legal post mortem procedures and their importance.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	identify the scope and need of forensic science in the present scenario.	Upto K6
CO 2	plan for the organizational setup and functioning of forensic science laboratories.	Upto K6
CO 3	analyze the biological samples found at the crime scene.	Upto K6
CO 4	perform extraction and identification of DNA obtained from body fluids.	Upto K6
CO 5	discuss the concept of forensic toxicology.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

Signature of the Chairman

FORENSIC SCIENCE

UNIT – I:

Forensic Science – Definition, history and development offorensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist.

UNIT – II:

Forensic science laboratories – Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology – Types and identification of microbial organisms of forensic significance.

UNIT – III:

Forensic serology – Definition, identification and examinationof body fluids – Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre.

UNIT – IV:

DNA profiling – Introduction, history of DNA typing.Extraction of DNA from blood samples – Organic and Inorganic extraction methods. DNA fingerprinting – RFLP, PCR, STR. DNA testing in disputed paternity.

UNIT – V:

Forensic toxicology – Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons – Types of poisons and their mode of action.

TEXT BOOKS:

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***. (6thEdition)Universal Press.
5. Richard Saferstein (2017). ***Criminalistics– An introduction to Forensic Science***. (12thEdition).Pearson Press.

Signature of the Chairman

REFERENCE BOOKS:

1. Nordby J. J. (2000). Dead Reckoning. ***The Art of Forensic Detection– CRC Press***, NewYork. 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.

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**2**	**3**	**3**	**3**
CO2	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**3**	**2**
CO4	**3**	**2**	**2**	**3**
CO5	**2**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE12	NANOBIOTECHNOLOGY	ELECTIVE 1 – II	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	

COURSE DESCRIPTION:

This course begins with a review of various types of nanomaterials and an introduction to general terminologies. Subsequently the course covers synthesis methodologies, physical and chemical characterization of nanomaterials.

COURSE OBJECTIVES:

- To analyse nanomaterials based on the understanding of nanobiotechnology.
- To discuss the methods of fabrication of nanomaterials.
- To provide knowledge on characterization of nanomaterials.
- To help the students discover nanomaterials for targeted drug delivery.
- To explain nanomaterials in nanomedicine and environmental pollution.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	employ knowledge in the field of nanobiotechnology for development.	Upto K6
CO 2	identify various applications of nanomaterials in the field of medicine and environment.	Upto K6
CO 3	examine the prospects and significance of nanobiotechnology.	Upto K6
CO 4	identify recent advances in this area and create a career or pursue research in the field.	Upto K6
CO 5	design non–toxic nanoparticles for targeted drug delivery.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

NANOBIOTECHNOLOGY

UNIT – I:

Introduction to nanobiotechnology, Nano size–changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First,second, third and fourth generation materials),Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials.

UNIT – II:

Fabrication of Nanomaterials–Top–down and Bottom–upapproaches, Solid phase synthesis–milling, Liquid phase synthesis–Sol–gel synthesis, colloidal synthesis, micro emulsion method, hydrothermal synthesis and solvo thermal synthesis, Vapour/Gas phase synthesis–Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles.

UNIT – III:

Characterization of nanoparticles – Based on particle size/morphology– Dynamic light scattering (DLS),Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy(AFM), Based on surface charge–zeta potential, Based on structure –X–ray diffraction (XRD), Fourier transform infrared spectroscopy(FTIR), Energy dispersive X–ray analysis (EDX),Based on optical properties– UV – Spectrophotometer, Based on magnetic properties–Vibrating sample magnetometer(VSM).

UNIT – IV:

Nanomaterial based Drug delivery and therapeutics–surface modified nano particles, MEMS/NEMS based devices,peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation.

UNIT – V:

Nanomaterials in diagnosis–Imaging, nanosensors indetection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions,organic and inorganic solutes and microorganisms.

TEXT BOOKS:

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:

1. Nouailhat A. (2008). ***An Introduction to Nanoscience and Nanotechnology***, Wiley.
2. Sharon M. and Maheshwar (2012). ***Bio–Nanotechnology: Concepts and Applications.*** NewDelhi. Ane books Pvt Ltd.
3. Niemeyer C.M. and Mirkin C. A. (2005). ***Nanobiotechnology***. Wiley Inter science.
4. Rehm, B. (2006). ***Microbial Bionanotechnology: Biological Self–Assembly Systems and Biopolymer–Based Nanostructures***. Horizon Scientific Press.
5. Reisner, D.E. (2009). ***Bionanotechnology: Global Prospects.*** CRC Press

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**2**	**3**	**3**	**2**
CO2	**3**	**2**	**2**	**3**
CO3	**3**	**3**	**2**	**2**
CO4	**2**	**3**	**2**	**3**
CO5	**3**	**3**	**2**	**3**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE13	MICROALGAL TECHNOLOGY	ELECTIVE 1– III	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

This course gives a detailed knowledge on Microalgal Technology**.**

COURSE OBJECTIVES:

- To characterize the different groups of algae.
- To describe the cultivation and harvesting of algae.
- To identify the commercial applications of various algal products.
- To apply microalgae for environmental applications.
- To employ microalgae as alternate fuels.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	acquire knowledge in the field of microalgal technology and their characteristics.	Upto K6
CO 2	identify the methods of algal cultivation and harvesting.	Upto K6
CO 3	recognize and recommend the use of microalgae as food, feed and fodder.	Upto K6
CO 4	promote microalgae in phycoremediation.	Upto K6
CO 5	compare and critically evaluate recent applied research in these microalgal applications.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MICROALGAL TECHNOLOGY

UNIT – I:
Introduction to Algae – General characteristics. Classification of algae according to Fritsch. Salient features of different groups of algae. Distribution – Freshwater, brackish water and marine algae. Identification methods. An overview of applied Phycology. Economically important microalgae.

UNIT – II:
Cultivation of freshwater and marine microalgae – Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation – Photobioreactors – construction, types and operation; raceway ponds – Heterotrophic and mixotrophic cultivation – Harvesting of microalgae biomass.

UNIT – III:
Microalgae in food and nutraceutical applications – Algal single cell proteins. Cultivation of *Spirulina* and *Dunaliella.* Microalgae as aquatic, poultry and cattle feed. Microalgal biofertilizers. Value–added products from microalgae. Pigments – Production of microalgal carotenoids and their uses. Phycobiliproteins – production and commercial applications. Polyunsaturated fatty acids as active nutraceuticals. Microalgal secondary metabolites – Pharmaceutical and cosmetic applications.

UNIT – IV:
Microalgae in environmental applications. Phycoremediation – Domestic and industrial waste water treatment. High–rate algal ponds and surface–immobilized systems – Treatment of gaseous wastes by microalgae. Sequestration of carbon dioxide. Scavenging of heavy metals by microalgae. Negative effects of algae. Algal blooms, algicides for algal control.

UNIT – V:
Microalgae as feed stock for production of biofuels – Carbon–neutral fuels. Lipid–rich algal strains – *Botryococcus braunii*. Drop–in fuels from algae – hydrocarbons and biodiesel, bioethanol, biomethane, biohydrogen and syngas from microalgae biomass. Biocrude synthesis from microalgae. Integrated biorefinery concept. Life cycle analysis of algae biofuels.

TEXT BOOKS:

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. ***Algal Biotechnology***. Daya Publishing House, New Delhi.

REFERENCE BOOKS:

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., Bauddh 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.

DIGITAL TOOLS:

1 https://www.classcentral.com/course/algae–10442
2 https://onlinecourses.nptel.ac.in/noc19_bt16/preview
3 https://freevideolectures.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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**2**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**2**
CO3	**3**	**2**	**2**	**2**
CO4	**3**	**3**	**2**	**3**
CO5	**3**	**3**	**2**	**3**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE14	BIOINSTRUMENTATION	ELECTIVE 2 – I	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

This course is an interdisciplinary field requiring a knowledge of the basic principles in several areas including digital electronic systems, control systems, detection systems, and material biocompatibility.

COURSE OBJECTIVES:

- To explain the principles and working mechanisms of laboratory instruments.
- To discuss chromatography techniques and molecular biology techniques.
- To illustrate molecular techniques in biological applications.
- To acquire knowledge on spectroscopic techniques
- To demonstrate the use of radio isotopes in various techniques.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	make use of the laboratory instruments– laminar air flow, pH meter, centrifugation methods, biosafety cabinetsfollowing SOP.	Upto K6
CO 2	apply chromatography techniques in the separation of biomolecules.	Upto K6
CO 3	perform molecular techniques like mutagenesis and theirdetection.	Upto K6
CO 4	estimate molecules in biological samples by adopting UV spectroscopic techniques.	Upto K6
CO 5	cultivate organisms anaerobically.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

BIOINSTRUMENTATION

UNIT – I:

Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets – Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation – Standard sedimentation coefficient – measurement of sedimentation co–efficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation – Applicationsin determination of molecular weight.

UNIT – II:

General principles of chromatography – Chromatographic Performance parameters; Types– Thin layer chromatography, Paper Chromatography, Liquid chromatography (LPLC &HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas liquid (GLC). Flash Chromatography and Ultra Performance convergence chromatography. Two dimensional chromatography. Stimulated moving bed chromatography (SEC).

UNIT – III:

Electrophoresis: Principle and applications – paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques –Southern, northern and western blotting.

UNIT – IV:

Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV– visible, FTIR spectrophotometer, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC–MS. Detection of molecules in living cells – FISH and GISH. Biophysical methods: Analysis of biomolecules by Spectroscopy UV/visible.

UNIT – V:

Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes – radioactive decay; Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger– Muller and Scintillation counters, auto radiography and its applications. Commonly used isotopes
in biology, labeling procedures and safety aspects.

TEXT BOOKS:

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:

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.

DIGITAL TOOLS:

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.

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**2**	**2**
CO2	**2**	**3**	**2**	**3**
CO3	**3**	**2**	**2**	**3**
CO4	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

Signature of the Chairman

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE15	HERBAL TECHNOLOGY AND COSMETIC MICROBIOLOGY	ELECTIVE 2 – II	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	✓	Skill Oriented		Entrepreneurship	✓

COURSE DESCRIPTION:

This course talks in detail about Herbal Technology and Cosmetic Microbiology**.**

COURSE OBJECTIVES:

- To impart knowledge of Indian Medicinal Plants and their applications in microbiology.
- To promote the technical skills involved in preparation of different types of plant extracts.
- To explain methods to analyze the antimicrobial activity of medicinal plants.
- To acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.
- To provide insight into pharmacopeia microbial assays and biosafety.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	identify the applications of Indian medicinal plants in treating diseases.	Upto K6
CO 2	identify and authenticate herbal plants.	Upto K6
CO 3	evaluate the antimicrobial activity of medicinal plants.	Upto K6
CO 4	describe the role of microorganisms and their metabolites in the preparation of cosmetics.	Upto K6
CO 5	validate procedures and biosafety measures in the mass production of cosmetics.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

HERBAL TECHNOLOGY AND COSMETIC MICROBIOLOGY

UNIT – I:
Herbs, Herbal medicine – Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.

UNIT – II:
Collection and authentication of selected Indian medicinal plants: *Emblica officinalis, Withania somnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Allium sativum*. Preparation of extracts – Hot and cold methods. Preparation of stock solutions.

UNIT – III:
Antimicrobial activity of selected Indian medicinal Plants: – In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well–diffusion methods. MIC – Macro and micro dilution techniques. Antiviral activity– cell lines– cytotoxicity, cytopathic and non–cytopathic effect.

UNIT – IV:
History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, – Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practicesin cosmetic manufacturing – HACCP protocols in cosmetic microbiology.

UNIT – V:
Cosmetic microbiology test methods – Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods – bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics – Global regulatory and toxicological aspect of cosmetic preservatives.

TEXT BOOKS:

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:

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 andQuality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issueson 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.
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.

DIGITAL TOOLS:

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/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**2**	**3**
CO2	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**2**
CO4	**3**	**3**	**2**	**3**
CO5	**3**	**3**	**2**	**3**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE16	ESSENTIALS OF LABORATORY MANAGEMENTAND BIOSAFETY	ELECTIVE – 2 – III	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

This course facilitates the students with the comparative knowledge of structured oriented programming and object oriented programming paradigm. It also provides the object oriented programming features which supports modular programming.

COURSE OBJECTIVES:

- To utilize containment principles to ensure biosafety.
- To enrich students' role and responsibilities of laboratory hazards and their control.
- To make the students 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 programmes.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	employ skills on laboratory safety and avoid laboratory accidents.	Upto K6
CO 2	prevent laboratory hazards by practicing safety strategies.	Upto K6
CO 3	practice various first aid procedures during common laboratory accidents.	Upto K6
CO 4	ensure biosafety strategies in laboratory.	Upto K6
CO 5	recognize the importance of biosafety guidelines.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

ESSENTIALS OF LABORATORY MANAGEMENTAND BIOSAFETY

UNIT – I:
Introduction to the laboratory and laboratory hazards – General laboratory facilities – Occupational safety– Lab accidents – Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan.

UNIT – II:
Common hazards in laboratory: Chemical hazards– Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling – Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards – Physical agent data sheets (PADS), Electric hazards– Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.

UNIT – III:
Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators.Disposal/Removal of PPE. Emergency equipment safety – Showers/ Eye Washes. Laboratory security and emergency response. First aid for – Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock.

UNIT – IV:
Biosafety – Historical background. Blood borne pathogens (BBP) and laboratory – acquired infections. Introduction to biological safety cabinets. Primary containment for biohazards. Biosafety levels of specific microorganisms. Recommended biosafety. Levels for infectious agents and infected animals. Risk groups with examples – Risk assessment. Safety levels. Case studies – Safe working, hand hygiene. Laboratory instruments, packing, sending, transport, import and export of biological agents. Hygiene, disinfection, decontamination, sterilization.

UNIT – V:
Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration. Recombinant DNA advisory committee(RDAC), Institutional biosafety committee(IBSC), Review committee on genetic manipulation(RCGM), Genetic engineering approval committee (GEAC). Implementation of biosafety guidelines.

TEXT BOOKS:

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. ***Medical Laboratory Technology***(4th Edition). CBS Publishers.
5. Ramakrishnan (2012). ***Manual of Medical Laboratory Techniques***. JP brothers.

REFERENCE BOOKS:

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. ***Clinical Laboratory Management*** (2nd Edition). ASM Press

DIGITAL TOOLS:

1. https://www.cdc.gov/labs/pdf/CDC– Biosafety microbiological BiomedicalLaboratories–2009–P.pdf
2. https://ucanapplym.s3.ap–south–1.amazonaws.com /RGU/notifications /E_learning /0nline_study/PG–SEM–IV– Biosafety%20regulation.pdf
3. https://consteril.com/biosafety–levels–difference/
4. https://www.cdc.gov/labs/pdf/CDC– Biosafety microbiological Biomedical Laboratories–2009–P.pdf
5. https://www.who.int/publications/i/item/9789240011311

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**2**
CO2	**2**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**3**
CO4	**3**	**3**	**3**	**2**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBS11	ENTREPRENEURSHIP IN BIOBUSINESS	Skill Enhancement Course – 1	2	–	2

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	I	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓		✓

COURSE DESCRIPTION:

The Entrepreneurship in Biobusiness Course provides the conceptual basis for understanding entrepreneurship, the role and importance of entrepreneurship for economic development. It covers proposal preparation, funding and face challenges in biobusiness.

COURSE OBJECTIVES:

- To make the students understand basic concepts in the area of entrepreneurship, the role and importance of entrepreneurship for economic development.
- To make the students develop personal creativity and entrepreneurial initiative, adopting the key steps in the elaboration of business idea.
- To make the students understand the stages of the entrepreneurial process and the resources needed for the successful development of entrepreneurial ventures.
- To explain the central components of successful business strategies in biotechnology, and create a business plan.
- To make the students acquire knowledge about proposal preparation, funding and face challenges in biobusiness.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	describe and apply several entrepreneurial ideas and businesstheories in practical framework.	**Upto K6**
CO 2	analyse the business environment in order to identify business opportunities, identify the elements of success of entrepreneurial ventures, evaluate the effectiveness of different entrepreneurial strategies and interpret their own business plan.	**Upto K6**
CO 3	express the mass production of microbial inoculants used as Biofertilizers and Bioinsecticides in response with field application and crop response.	**Upto K6**
CO 4	analyze the application and commercial production Monoclonal antibodies, Cytokines. TPH and teaching kits.	**Upto K6**
CO 5	integrate and apply knowledge of the regulation of biotechnology industries, utilize effective team work skills within an effective management team with a common objective, and gain effective team work skills, with an awareness of cultural diversity and social inclusiveness.	**Upto K6**

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

ENTREPRENEURSHIP IN BIOBUSINESS

UNIT – I:

Bio Entrepreneurship – Introduction to bio–business, SWOT analysis of bio–business. Ownership. Development of Entrepreneurship. Stages in entrepreneurial process. Government schemes and funding. Small scale industries – Definition, characteristics, need and rationale.

UNIT – II:

Entrepreneurship opportunity in agricultural Microbiology – Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope. Case study on Plant cell and tissue culture technique, polyhouse culture. Herbal bulk drug production, nutraceuticals, value added herbalproducts. Bioethanol production using agricultural waste, algal source. Integration of system biology for agricultural applications. Biosensor development in agri management.

UNIT – III:

Entrepreneurship opportunity in industrial biotechnology – Business opportunity, Essential requirement, marketing strategies, schemes, challenges, and scope. Pollution monitoring and Bioremediation for Industrial pollutants. Integrated compost production – microbe enriched compost. Bio pesticide/ insecticide production. Biofertilizers. Single cell protein.

UNIT – IV:

Therapeutic and Fermented products – Stem cell production,stem cell bank, production of monoclonal/polyclonal antibodies, secondary metabolite production – antibiotics, probiotic and prebiotics.

UNIT – V:

Project Management, Technology Management and Startup Schemes – Building Biotech business challenges in Indian context – biotech partners (BIRAC, DBT, Incubation centers. etc.,), operational biotech parks in India. Indian Company act for Biobusiness – schemes and subsidies. Project proposal preparation, Successful start–ups–case study.

TEXT BOOKS:

1. Shimasaki C. (2014). ***Biotechnology Entrepreneurship: Starting, Managing, andLeading Biotech Companies***– Academic Press. ISBN: 978–0–12–404730–3
2. Acton A. Q. (2021). ***Biological Pigments – Advances in Research and Application–***(Scholarly Editions). Atlanta, Georgia. ISBN: 978–1–481–68574–0
3. Stanbury P. F. and Whitekar**.** A. ***Principles of Fermentation Technology***, (3rd Edition).Butterworth–Heinemann. ISBN 10: 0080999530
4 Anil Kumar (2020). ***Small Business and Entrepreneurship, Willey Distributions***, Dream Tech Press.
5 Angi Redy (2015). ***An Unfinished Agenda***. ISBN 139780670087808.

REFERENCE BOOKS:

1. Crueger, W, and Crueger. A. (2017). ***Biotechnology: A Text Book of Industrial Microbiology***. (2nd Edition). Medtech. ISBN–10 : 9385998633
2. Teng P. S. (2008). ***Bioscience Entrepreneurship in Asia.*** World Scientific Publishing Company. 2008.
3. Agarwal S., Kumari S. and Khan S. (2021). ***Bioentrepreneurship and Transferring Technology into Product Development.*** Business Science Reference. ISBN–10:1799874125
4. Krishnamurthy A.G. ***Dirubai Ambani Against All Odds***. McGraw Hills.
5. Peter F. Drucker. ***Innovation and Entrepreneurship*** (1985).

DIGITAL TOOLS:

1. https://www.profitableventure.com/biotech–business–ideas/
2. https://www.bio–rad.com/webroot/web/pdf/lse/literature/Biobusiness.pdf
3. https://www.nature.com/articles/s41587–021–01110–3
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3003900/
5. https://springhouse.in/government–schemes–every–entrepreneur/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**2**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**2**
CO3	**2**	**3**	**2**	**2**
CO4	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE STRUCTURE – II SEMESTER

S. No.	Sub. Code	Subject Title	Hrs./ Week	Exam (Hrs.)	CA	SE	Total	Credits
1	23PMBC21	**Core – 4:** Medical Bacteriology and Mycology	6	3	25	75	100	5
2	23PMBC22	**Core – 5:** Medical Virology and Parasitology	6	3	25	75	100	5
3	23PMBCP2	**Core – 6:** Practical – II – Medical Microbiology	6	6	40	60	100	4
4	**Elective–3:**		5	3	25	75	100	3
	23PMBE21	Epidemiology						
	23PMBE22	Clinical and Diagnostic Microbiology						
	23PMBE23	Bioremediation						
5	**Elective – 4:**		5	3	25	75	100	3
	23PMBE24	Bioinformatics						
	23PMBE25	Biosafety, Bioethics and IPR						
	23PMBE26	Clinical Research and Clinical Trials						
6	23PMBS21	**Skill Enhancement Course-2:** Vermitechnology	2	3	25	75	100	2
		TOTAL	30					22

CA – Class Assessment (Internal)

SE – Summative Examination

T – Theory

P – Practical

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC21	MEDICAL BACTERIOLOGY AND MYCOLOGY	CORE – 4	6	–	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	✓	Skill Oriented	✓	Entrepreneurship	

COURSE DESCRIPTION:

This course provides the students with basic theoretical and practical aspects of various groups of microorganisms to include bacteriology, virology, mycology and various immunodiagnostic methods to detect fungal infections.

COURSE OBJECTIVES:

- To make the students acquire knowledge on collection, transportation and processing of various kinds of clinical specimens.
- To explain morphology, characteristics and pathogenesis of bacteria.
- To discuss various factors leading to pathogenesis of bacteria.
- To make the students acquire knowledge on antifungal agents and their importance.
- To describe various diagnostic methods available for fungal disease diagnosis.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	collect, transport and process of various kinds of clinical specimens.	Upto K6
CO 2	analyze various bacteria based on morphology and pathogenesis.	Upto K6
CO 3	discuss various treatment methods for bacterial disease.	Upto K6
CO 4	employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents.	Upto K6
CO 5	apply various immunodiagnostic method to detect fungal infections.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MEDICAL BACTERIOLOGY AND MYCOLOGY

UNIT – I:

Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.

UNIT – II:

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci, Neisseriae*., *Bacillus, Corynebacteria, Mycobacteria* and *Clostridium.*

UNIT – III:

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, *Yersinia, Pseudomonas, Vibrio, Mycoplasma, Helicobacter, Rickettsiae, Chlamydiae, Bordetella, Francisella., Spirochaetes– Leptospira, Treponema* and *Borrelia*. Nosocomial, zoonotic and opportunistic infections –prevention and control.

UNIT – IV:

Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. *Trichophyton, Epidermophyton & Microsporum*. Yeasts of medical importance – *Candida, Cryptococcus*. Mycotoxins. Antifungal agents, testing methods and quality control.

UNIT – V:

Dimorphic fungi causing Systemic mycoses, *Histoplasma, Coccidioides, Sporothrix, Blastomyces.* Fungi causing Eumycotic Mycetoma, Opportunistic fungi– Fungi causing secondary infections in immunocompromised patients. Immunodiagnostic methods in mycology– Recent advancements in diagnosis.Antifungal agents.

TEXT BOOKS:

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:

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.
5. Murray P.R., Rosenthal K.S. and Michael A. (2013). ***Medical Microbiology.*** P faller.7th edn. Elsevier, Mosby Saunders.

DIGITAL TOOLS:

1. http://textbookofbacteriology.net/nd
2. https://microbiologysociety.org/members–outreach–resources/links.html
3. https://www.pathelective.com/micro–resources
4. http://mycology.cornell.edu/fteach.html
5. https://www.adelaide.edu.au/mycology/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**2**
CO4	**3**	**3**	**3**	**2**
CO5	**3**	**3**	**3**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBC22	MEDICAL VIROLOGY AND PARASITOLOGY	CORE – 5	6	–	5

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	

COURSE DESCRIPTION:

This scientific discipline is concerned with the study of the biology of viruses and viral diseases. The Course also talks about the protozoans and helminthes present in stool and blood specimens.

COURSE OBJECTIVES:

- To describe the replication strategy and cultivation methods of viruses.
- To make the students acquire knowledge about oncogenic virus and human viral infections.
- To make the students develop diagnostic skills, in the identification of virus infections.
- To impart knowledge about parasitic infections.
- To make the students develop diagnostic skills, in the identification of parasitic infections.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay.	Upto K6
CO 2	investigate the symptoms of viral infections and presumptively identify the viral disease.	Upto K6
CO 3	diagnose various viral diseases bydifferent methods.(serological, conventional and molecular)	Upto K6
CO 4	educate public about the spread, control and prevention of parasitic diseases.	Upto K6
CO 5	identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

MEDICAL VIROLOGY AND PARASITOLOGY

UNIT – I:

General properties of viruses – Structure and Classification –viroids, prions, satellite RNAs and virusoids. Cultivation of viruses – embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end–point).

UNIT – II:

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 , RNA Viruses– Picorna, Orthomyxo, Paramyxo, Rhabdo, Rota, HIV and other Hepatitis viruses, Arbo – Denguevirus, Ebola virus, Emerging and reemerging viral infections.

UNIT – III:

Bacterial viruses – ΦX 174, M13, MU, T4, lambda, Pi;Structural organization, life cycle and phage production. Lysogenic cycle–typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines.

UNIT – IV:

Introduction to Medical Parasitology – Classification, host– parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba,* Aerobic and Anaerobic amoebae, *Giardia, Trichomonas,Balantidium. Toxoplasma, Cryptosporidium, Leishmania,* and *Trypanasoma.*

UNIT – V:

Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes – Cestodes – *Taenia Solium, T. Saginata, T. Echinococcus*. Trematodes – *Fasciola Hepatica, Fasciolopsis Buski, Paragonimus, Schistosomes*. Nematodes – *Ascaris, Ankylostoma, Trichuris, Trichinella, Enterobius, Strongyloides* and *Wuchereria*. Other parasites causing infections in immune compromised hosts and AIDS. Cultivation of parasites. Diagnosis of parasitic infections – Serological and molecular diagnosis. Anti–protozoan drugs.

TEXT BOOKS:

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:

1. Carter J. (2001). ***Virology: Principles and Applications*** (1st Edition). Wiley Publications.
2. Willey J., Sandman K. and Wood D. Prescott ***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.
5. Levanthal R. and Cheadle R. S. (2012). ***Medical Parasitology***. (6th Edition). S.A. Davies Co. Philadelphia.

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**1**	**3**	**3**	**3**
CO2	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**2**
CO4	**3**	**2**	**3**	**2**
CO5	**3**	**3**	**2**	**3**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBCP2	PRACTICAL II – MEDICAL MICROBIOLOGY	CORE – 6	–	6	4

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	40	60	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓		✓

COURSE DESCRIPTION:

The practical provides practical training to the students in the fields of Medical Microbiology, of different clinical samples, transport, culture, examination and identification of arthropod vectors.

COURSE OBJECTIVES:

- To develop skills in the diagnosis of bacterial infections and antimicrobial sensitivity.
- To impart knowledge on fungal infections and its diagnosis.
- To make the students know about cultivation, identification and assay of viruses for diagnostics and vaccine production
- To diagnose parasitic infections.
- To make the students identify medically important vectors.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	understand collection of different clinical samples, transport, culture and examination.	Upto K6
CO 2	identify medically important fungus from the clinical samples.	Upto K6
CO 3	perform and Interpret serological tests for viral diseases.	Upto K6
CO 4	exam and identify ova and cyst in samples.	Upto K6
CO 5	understand collection and identification of arthropod vectors.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

PRACTICAL II – MEDICAL MICROBIOLOGY

UNIT – I:

Staining of clinical specimens – Wet mount, Differential and Special staining methods. Isolation and identification of bacterial pathogens from clinical specimens – cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests. Enumeration of bacteria in urine to detect significant bacteriuria. Antimicrobial sensitivity testing – Kirby Bauer method and Stokes method. Minimum inhibitory concentration (MIC) test. Minimum bactericidal concentration (MBC) test.

UNIT – II:

Identification and Classification of common fungi. Examination of different fungi by Lactophenol cotton blue staining. Examination of different fungi by KOH staining. Cultivation of fungi and their identification – *Mucor, Rhizopus, Aspergillus, Penicillium.*Microscopic observation of different asexual fungal spores. Microscopic observation of fungal fruiting bodies.Identification of Dermatophytes.

UNIT – III:

Isolation and characterization of bacteriophage fromnatural sources by phage titration. Cultivation of viruses –Egg Inoculation methods. Diagnosis of Viral Infections –ELISA – HIA. Spotters of viral inclusions and CPE–stained smears.

UNIT – IV:

Examination of parasites in clinical specimens – Ova/cysts in faeces. Concentration: methods – Floatation methods– simple Saturated salt solution method – Zinc sulphate methods – Sedimentation methods– Formal ether method. Blood smear examination for malarial parasites. Thin smear by Leishman's stain – Thick smear by J.B. stain.

UNIT – V:

Identification of common arthropods of medicalimportance–spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites.

TEXT BOOKS:

1. Cullimore D. R. (2010). ***Practical Atlas for Bacterial Identification***, 2nd Edn. 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. Cappuccimo, J. and Sherman, N. (2002) ***Microbiology: A Laboratory Manual,*** (6thEdition). Pearson Education, Publication, New Delhi.
5. Morag C. and Timbury M.C. (1994***). Medical Virology***. 4th edn. Blackwell Scientific Publishers.

REFERENCE BOOKS:

1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). ***Mackie & McCartney Practical Medical Microbiology***. (14th Edition). Elsevier, NewDelhi.
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

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**2**	**3**	**3**	**2**
CO2	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**2**	**2**
CO4	**3**	**2**	**3**	**2**
CO5	**3**	**3**	**2**	**3**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE21	EPIDEMIOLOGY	ELECTIVE 3 – I	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	

COURSE DESCRIPTION:

This course is designed to provide students with an overview of the principles and practices of infectious diseases epidemiology with focus on how the presence and control of communicable diseases affects public health locally, nationally, and internationally.

COURSE OBJECTIVES:

- To describe the role of epidemiology in public health.
- To explain about epidemiology tools and disease surveillance methods.
- To make the students analyze various communicable and non–communicable diseases in India.
- To discuss on mechanism of antimicrobial resistance.
- To outline on National health programmes that have been designed to address the issues.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apply the knowledge acquired on concepts of epidemiology to clinical and public health environment.	Upto K6
CO 2	plan various strategies to trace the epidemiology.	Upto K6
CO 3	plan the control of communicable and non–communicable diseases.	Upto K6
CO 4	analyze the implications of drug resistance in the society and design the control of antimicrobial resistance and its management.	Upto K6
CO 5	employ National control programs related to Communicable and Non–Communicable diseases with the public.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

EPIDEMIOLOGY

UNIT – I:

Fundamentals of epidemiology – Definitions of epidemiology –Epidemiology of infectious diseases in Public Health. Natural history of disease – Historical aspects of epidemiology. Common risk factors – Epidemiologic Triad – Agent factors, host factors and environmental factors. Transmission basics – Chain of infection, portal of entry. Modes of transmission – Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis – Factors, routes of transmission of bacterial, viral, parasitic and fungal zoonotic agents. Control of zoonosis.

UNIT – II:

Tools of Epidemiology – Measures of Disease – Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology – Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies – Disease surveillance, geographical indication system, outbreak investigation in public health and contact investigation.

UNIT – III:

Epidemiological aspects of diseases of national importance – Background to communicable and non–communicable diseases. Vector borne diseases in India. Diarrhoeal diseases. Zoonoses. Viral haemorrhagic fevers. Mycobacterial infections. Sexually transmitted diseases. Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). Emerging disease threats – Severe Acute Respiratory Syndrome (SARS), Covid–19, Ebola, MDR–TB, Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non–communicable diseases – Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re–emerging Diseases.

UNIT – IV:

Mechanisms of Antimicrobial resistance – Multidrug Efflux pumps, Extended Spectrum β–lactamases (ESBL). Hospital acquired infections – Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of *Pseudomonas, Acinetobacter, Clostridium difficile,* HBV, HCV, Rotavirus, *Cryptosporidium* and *Aspergillus* in Nosocomial infections. Prevention and management of nosocomial infections.

UNIT – V:

National Programmes related to Communicable and Non– Communicable diseases – National Malaria Eradication Programme, Revised National Tuberculosis Control Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme. Biochemical and immunological tools in epidemiology – Biotyping, Serotyping, Phage typing, FAME (Fatty acid methyl ester analysis), Curie Point PyMS (Pyrolysis Mass spectrometry), Protein profiling, Molecular typing methods.

TEXT BOOKS:

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.

REFERENCE BOOKS:

1. Bhopal R. S. (2016).***Concepts of Epidemiology – An Integrated Introduction to theIdeas, 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). Elseiver, 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.

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**2**
CO2	**3**	**2**	**2**	**3**
CO3	**2**	**3**	**2**	**2**
CO4	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE22	CLINICAL AND DIAGNOSTIC MICROBIOLOGY	ELECTIVE 3 – II	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	✓	Skill Oriented		Entrepreneurship	✓

COURSE DESCRIPTION:

This Course discusses Clinical and Diagnostic Microbiology in detail.

COURSE OBJECTIVES:

- To describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management.
- To develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab.
- To elucidate various diagnostic procedures in microbiology.
- To make the students acquire knowledge on different methods employed to check antibiotic sensitivity.
- To make the students gain knowledge on hospital acquired infections and their control measures.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apply Laboratory safety procedures and hospital waste disposal strategies.	Upto K6
CO 2	collect various clinical specimens, handle, preserve and process safely.	Upto K6
CO 3	identify the causative agents of diseases by conventional and molecular methods following standard protocols.	Upto K6
CO 4	assess the antimicrobial susceptibility pattern of pathogens.	Upto K6
CO 5	trace the sources of nosocomial infection and recommend control measures.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

CLINICAL AND DIAGNOSTIC MICROBIOLOGY

UNIT – I:
Microbiology Laboratory Safety Practices –General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal – Biomedical waste management, Emerging and Re–emerging infections.

UNIT – II:
Diagnostic procedures – General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory – Specimen acceptance and rejection criteria.

UNIT – III:
Diagnosis of microbial diseases – Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis.

UNIT – IV:
Antibiotic sensitivity tests – Disc diffusion – Stokes and Kirby Bauer methods, E test – Dilution – Agar dilution & broth dilution – MBC/MIC – Quality control for antibiotics and standard strains.

UNIT – V:
Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and controlmeasures. Hospital Infection Control Committee (HICC) – Functions.

TEXT 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. 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:

1. Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Yolken R.H. (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.
3. 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.
4. Koneman E.W., Allen S. D., Schreckenberg P. C. and Winn W. C. (2020). ***Koneman's Color Atlas and Textbook of Diagnostic Microbiology.*** (7th Edition). Jones & BartlettLearning. ISBN:1284322378 9781284322378.
5. 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.

DIGITAL TOOLS:

1. https://www.ncbi.nlm.nih.gov/books/NBK20370/
2. https://www.msdmanuals.com/en–in/home/infections/diagnosis–of–infectious3disease/diagnosis–of–infectious–disease
3. https://journals.asm.org/doi/10.1128/JCM.02592–20
4. https://www.sciencedirect.com/science/article/pii/S2221169116309509
5. http://www.textbookofbacteriology.net/normalflora_3.html

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**2**	**3**	**2**
CO2	**3**	**3**	**2**	**2**
CO3	**2**	**3**	**3**	**2**
CO4	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE23	BIOREMEDIATION	ELECTIVE 3 – III	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

Bioremediation is a branch of biotechnology that employs the use of living organisms, like microbes and bacteria, in the removal of contaminants, pollutants, and toxins from soil, water, and other environments.

COURSE OBJECTIVES:

- To describe the nature and importance of bioremediation and use in real world applications.
- To describe the typical composition of waste water and application of efficient technologies for water treatment.
- To explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.
- To explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.
- To familiarize the students the role of plants and their associated microbes in remediation and management of environmental pollution.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	differentiate Ex–situ bioremediation and In–situ bioremediation. Assess the roles of organisms in bioremediation.	Upto K6
CO 2	distinguish microbial processes necessary for the design and optimization of biological processing unit operations.	Upto K6
CO 3	identify, formulate and design engineered solutions to environmental problems.	Upto K6
CO 4	explore microbes in degradation of toxic wastes and playing role on biological mechanisms.	Upto K6
CO 5	establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting *Rhizobacteria* in phytoremediation.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

BIOREMEDIATION

UNIT – I:

Bioremediation – process and organisms involved. Bioaugmentation – Ex–situ and in–situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process.

UNIT – II:

Microbes involved in aerobic and anaerobic processes in nature. Water treatment – BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. Secondary waste water treatments – use of membrane bioreactor. Aquaculture effluent treatment. Aerobic sludge and landfill leachate process. Aerobic digestion.

UNIT – III:

Composting of solid wastes, anaerobic digestion – methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromatic compounds. Bioremediation of dyes, bioremediation in paper and pulp industries. Aerobic and anaerobic digesters – design. Various types of digester for bioremediation of industrial effluents.

UNIT – IV:

Microbial leaching of ores – process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation – reductive and oxidative. Dechlorination. Biodegradable of plastics and super bug.

UNIT – V:

Phytoremediation of heavy metals in soil – Basic principles of phytoremediation – Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation. Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting Rhizobacteria in phytoremediation.

TEXT BOOKS:

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:

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.
2. Singh A. and Ward O. P. (2004). ***Biodegradation and Bioremediation.*** Soil Biology. 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.*** 1stedition. I.K. International Publishing House Pvt. Ltd.

DIGITAL TOOLS:

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
5. https://microbiologysociety.org/blog/bioremediation–the–pollution–solution.html

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**2**
CO2	**3**	**3**	**2**	**2**
CO3	**3**	**3**	**2**	**2**
CO4	**3**	**3**	**2**	**2**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE24	BIOINFORMATICS	ELECTIVE 4 – I	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	✓

COURSE DESCRIPTION:

Bioinformatics, as related to genetics and genomics, is a scientific subdiscipline that involves using computer technology to collect, store, analyze and disseminate biological data and information, such as DNA and amino acid sequences or annotations about those sequences.

COURSE OBJECTIVES:

- To discuss various biological data mining concepts, tools.
- To elucidate the principles and applications of sequence alignment methods and tools.
- To demonstrate different phylogenetic tree construction methods and its uses in phylogenetic analysis.
- To make the students acquaint with various approaches in predicting 3D and 2D structure of proteins.
- To describe various tools and techniques used in molecular docking, immune informatics and subtractive genomics.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	access to databases that provides information on nucleic acidsand proteins.	Upto K6
CO 2	invent algorithms for sequence alignment.	Upto K6
CO 3	construct phylogenetic tree.	Upto K6
CO 4	predict the structure of proteins.	Upto K6
CO 5	design drugs by predicting drug ligand interactions and molecular docking.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

BIOINFORMATICS

UNIT – I:

Biological Data Mining – Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases. Concept of Alignment, Pairwise Sequence Alignment (PSA), Multiple Sequence Alignment (MSA), BLAST, CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

UNIT – II:

Phylogenetic Tree Construction – Concept of Dendrograms. Evolutionary Trees – Distance Based Tree Reconstruction – Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices – Evolutionary Trees and Hierarchical Clustering – Character Based Tree Reconstruction – Maximum Parsimony Method, Maximum likelihood method – Reliability of Trees – Substitution matrices – Evolutionary models.

UNIT – III:

Computational Protein Structure prediction – Secondary structure – Homology modelling– Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment –Prediction of function from structure. Geometrical parameters –Potential energy surfaces – Hardware and Software requirements–Molecular graphics – Molecular file formats– Molecular visualization tools.

UNIT – IV:

Prediction of Properties of Ligand Compounds – 3D Autocorrelation –3D Morse Code– Conformation Dependent and Independent Chirality Codes –Comparative Molecular Field Analysis – 4 D QSAR –HYBOT Descriptors – Structure Descriptors – Applications – Linear Free Energy Relationships – Quantity Structure – Property Relationships – Prediction of the Toxicity of Compounds.

UNIT – V:

Molecular Docking– Flexible – Rigid docking– Target– Ligand preparation– Solvent accessibility– Surface volume calculation, Active site prediction– Docking algorithms– Genetic, Lamarckian – Docking analyses– Molecular interactions, bonded and nonbonded – Molecular Docking Software and Working Methods. Genome to drug discovery – Subtractive Genomics – Principles of Immunoinformatics and Vaccine Development.

TEXT BOOKS:

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. Addision.***Wesley Longman Limited, England.
5. Mount D.W., (2013).***Bioinformatics Sequence and Genome Analysis***, 2nd edn.CBSPublishers, New Delhi.

REFERENCE BOOKS:

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.
5. Harshawardhan P.Bal, (2006). ***Bioinformatics Principles and Applications***, TataMcGraw–Hill Publishing Company Limited.

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**1**	**3**	**3**	**2**
CO2	**3**	**2**	**3**	**3**
CO3	**3**	**2**	**3**	**2**
CO4	**3**	**3**	**2**	**2**
CO5	**3**	**3**	**2**	**3**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE25	BIOSAFETY, BIOETHICSAND IPR	ELECTIVE 4 – II	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	☐	✓	☐

COURSE DESCRIPTION:

This Course provides a broad coverage of three areas of patenting-**intellectual property rights** (**IPR**), **biosafety** and **bioethics**.

COURSE OBJECTIVES:

- To create a research environment and encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine.
- To discuss various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products.
- To familiarize the students with fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries.
- To help the students acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops
- To provide students with an understanding of bioethics in research associated with medicine

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	execute the role of IPR, Patent, Trademarks and its importance.	Upto K6
CO 2	develop patent procedure, patent filling and its mapping.	Upto K6
CO 3	become Patent attorneys and Patent officers.	Upto K6
CO 4	apply bioethics in GMO, food crops and its biodiversity.	Upto K6
CO 5	analyze the importance of bioethics in research associated with HGP, clinical research, stem cell therapy.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

BIOSAFETY,BIOETHICSAND IPR

UNIT – I:

Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology – Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non– disclosure agreements. Patent life and geographical boundaries. International organizations and IPR – Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries.

UNIT – II:

Process involved in patenting. Patent Search – Procedural steps in patenting, process of filing, PCT application, pre– grant & post–grant opposition, PCT and patentharmonization including Sui–generis system, patent searchmethods, patent databases and libraries, online tools, Country–wise patent searches (USPTO, EPO, India etc.), patent mapping.

UNIT – III:

Patentability of biotechnology inventions – Patentability of biotechnology inventions in India, statutory provisionsregarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005). Biotechnological inventions as patentable subject matter, territorial nature of patents – from territorial to global patent regime, interpreting trips in the light of biotechnology inventions, feasibility of a uniform global patent system, merits and demerits of uniform patent law, relevance of the existing international patent, tentative harmonisation efforts, implications of setting up a uniform world patent system.

UNIT – IV:

Introduction to bioethics – need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity – conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. 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.

UNIT – V:

Bioethics in medicine – Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning – permissions and procedures in animal cloning, human cloning, risks andhopes. Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. he Nuremberg code.

TEXT BOOKS:

1. Usharani B., Anbazhagi S. and Vidya C. K. (2019). ***Biosafety in Microbiological Laboratories.*** (1st Edition). Notion Press. ISBN–101645878856
2. Satheesh M. K. (2009). ***Bioethics and Biosafety***. (1st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703
3. Goel D. and Parashar S. (2013). IPR, ***Bio safety and Bioethics***. (1st Edition). Pearson education: Chennai. ISBN–13: 978–8131774700
4. Raj Mohan joshi. ***Biosafety and Bioethics***. Wiley Publications.
5. Sibi. G. ***Intellectual Property Rights, Bioethics, Biosafety and Entrepreneurship in Biotechnology.*** (2021). Wiley Publications.

REFERENCE BOOKS:

1. Nithyananda K. V. (2019). ***Intellectual Property Rights: Protection and Management***, India, IN: Cengage Learning India Private Limited.
2. Neeraj, P. and Khusdeep, D. (2014). ***Intellectual Property Rights***, India, IN: PHI learning Private Limited,
3. Ahuja, V K. (2017). ***Law relating to Intellectual Property Rights,*** India, IN: LexisNexis.
4. Tony Hope (2004). ***Medical Ethics: A very Short Introduction***. Oxford Publication.
5. Goel Parashar. ***IPR, Biosafety and Bioethics*** (2013). Pearson Publications.

DIGITAL TOOLS:

1. http://www.bdu.ac.in/cells/ipr/docs/ipr–eng–ebook.pdf.
2. https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub _489.pdf.
3. https://www.cdc.gov/training/quicklearns/biosafety/
4. https://bioethics.msu.edu/what–is–bioethics
5. https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	2
CO2	2	3	2	2
CO3	3	3	2	3
CO4	3	3	2	3
CO5	3	2	2	3

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBE26	CLINICAL RESEARCH ANDCLINICAL TRIALS	ELECTIVE 4 – III	5	–	3

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓	✓	

COURSE DESCRIPTION:

This Course deals with Clinical Research and Clinical Trials.

COURSE OBJECTIVES:

- To provide an overview of history and methods involved in conducting clinical research.
- To design the principles involved in ethical, legal, and regulatory issues in clinical research on human subjects.
- To describe principles and issues involved in monitoring patient–oriented research.
- To formulate a well– defined quality assurance and quality control plans.
- To help the students acquire business development skills in the area of clinical research.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	apprehend the Drug Development process and different phases of clinical trials.	Upto K6
CO 2	recognize the ethics and regulatory perspectives on clinical research trials activities.	Upto K6
CO 3	accentuate about clinical trials management concepts and documentation process.	Upto K6
CO 4	accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trialresults.	Upto K6
CO 5	nurture skills recitation to commercial start up and industriousness.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

CLINICAL RESEARCH ANDCLINICAL TRIALS

UNIT – I:

Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase–I), Therapeutic Exploratory trail (Phase–II), Therapeutic Confirmatory Trail (Phase–III) and Post marketing surveillance (Phase–IV).

UNIT – II:

Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research–Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)–Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research– Drug and cosmetic act, FDA, Schedule–Y– Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process– IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities– EMEA, MHRA, PhRMA.

UNIT – III:

Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board, Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements – Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research –IB, ICF, PIS, TMF, ISF, CDA & CTA.

UNIT – IV:

Quality Assurance, Quality Control & Clinical Monitoring: Defining the terminology– Quality, Quality system, Quality Assurance & Quality Control–QA audit plan. 21 CRF Part 11, Site Auditing, Sponsor Compliance and Auditing, SOP
For Clinical Research–CRF Review & Source Data Verification, Drug Safety Reporting Corrective and preventative action process.

UNIT – V:

Business Development in the Clinical Research Industry: Introduction & Stages of Business Development–Start–up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical
Research. Role of business development manager.

TEXT BOOKS:

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.
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. ***Text book of Clinical Research***, Pee Vee books.

REFERENCE BOOKS:

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. Peppler, 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.

DIGITAL TOOLS:

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

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**2**	**3**	**3**	**3**
CO2	**3**	**2**	**2**	**2**
CO3	**3**	**3**	**2**	**3**
CO4	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

COURSE CODE	COURSE TITLE	CATEGORY	T	P	CREDITS
23PMBS21	VERMITECHNOLOGY	Skill Enhancement Course – 2	2	–	2

YEAR	SEMESTER	INTERNAL	EXTERNAL	TOTAL
I	II	25	75	100

NATUREOF COURSE	Employability	Skill Oriented	Entrepreneurship
	✓		✓

COURSE DESCRIPTION:

Vermitechnology includes the study and commercial application of technologies that utilise earthworms for degrading waste organic materials for sanitation and agricultural re-use.

COURSE OBJECTIVES:

- To introduce the concepts of vermicomposting.
- To explain the physiology, anatomy and biology of earthworms.
- To help the students acquire the knowledge of the vermicomposting process.
- To explain the trouble shooting, harvesting and packaging of vermin composts.
- To help the students gain knowledge on applications of vermin composts and their value added products.

COURSE OUTCOMES (COs):

After the completion of the course, the students will be able to

No.	Course Outcomes	Knowledge Level (According to Bloom's Taxonomy)
CO 1	compare and contrast the uses of vermicom post to the soil.	Upto K6
CO 2	recommend different species of earthworms after acquiring knowledge on its biology.	Upto K6
CO 3	design the vermicomposting process.	Upto K6
CO 4	assess the Best Practices of Vermicomposting	Upto K6
CO 5	recommend the applications of vermicom post to different soils and for different crops.	Upto K6

K1 – KNOWLEDGE (REMEMBERING), K2 – UNDERSTANDING, K3 – APPLY, K4 – ANALYZE, K5 – EVALUATE, K6 – CREATE

VERMITECHNOLOGY

UNIT – I:

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.

UNIT – II:

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).

UNIT – III:

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– 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.

UNIT – IV:

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.

UNIT – V:

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.

TEXT BOOKS:

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 The complete technology book on ***Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout***. AB Press.
5 Keshav Singh (2014). ***A Textbook of Vermicompost: Vermiwash and Biopesticide***.

REFERENCE BOOKS:

1. Roy D. (2018). ***Handbook of Vermitechnology***. Lambert Academic Publishing.
2. Kumar A. (2005). ***Verms and Vermitechnology***, A.P.H. Publishing Corporation, NewDelhi.
3. Lekshmy M. S., Santhi R. (2012). ***Vermitechnology,*** Sara Publications, New Delhi, India.
4. Edwards CA, Arancon NQ ShermanRL. (2011) ***Vermiculture Technology***: ***Earthworms,Organic Wastes, and Environmental Management*** .1st edn.CRC Press.
5. Ismail, S.A. (1997). ***Vermicology–The Biology of Earthworm***.1st edn. Orient longman.

DIGITAL TOOLS:

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_202101280320462 9.pdf
4. https://composting.ces.ncsu.edu/vermicomposting–2/
5. https://rodaleinstitute.org/science/articles/vermicomposting–for–beginners/

Mapping of CO with PSO

	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**3**	**3**	**2**
CO2	**2**	**3**	**2**	**3**
CO3	**3**	**3**	**2**	**3**
CO4	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**2**	**2**

3. Advanced Application 2. Intermediate Development 1. Introductory Level

METHODS OF EVALUATION		
Internal Evaluation	Continuous Internal Assessment Test	**25 Marks**
	Assignments / Snap Test / Quiz	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	**75 Marks**
Total		**100 Marks**

METHODS 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