MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI – 12

MODIFIED AND CORRECTED SYLLABUS
(RECEIVED FROM CHAIRPERSON ON 6.10.2023.)

M.Sc Microbiology

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005

FROM THE ACADEMIC YEAR 2023 – 2024

Programme:	**M.Sc. MICROBIOLOGY**
Programme code:	**22PGMB**
Duration:	**2 Years [PG]**
Programme Outcomes:	**PO1: Disciplinary Knowledge** Capable of demonstrating detailed knowledge and expertise in all the disciplines of the subject. **PO2: Communication Skills** Able to express thoughts, ideas, concepts, scientific information, experiments and its significance effectively in writing and verbal, communicate with confidence to different groups, using appropriate media. **PO3: Moral and Ethical Awareness** Ability to employ values in conducting one's life, use ethical practice at work, avoiding fabrication, misinterpretation and plagiarism, adhering to intellectual property rights and appreciate ethical solutions for environmental sustainability. **PO4: Analytical Reasoning** Ability to evaluate the reliability and relevance of evidence, identify flaws, analyze and synthesize data from different sources. **PO5: Contribution to Society** Solve public issues concerned with public health and safety for the welfare of the society. **PO6: Scientific Reasoning** Ability to identify, analyze, interpret and draw conclusions from qualitative and quantitative data, critically evaluate ideas, evidences and experiences,

	with an open mind and reasoned perspective. **PO7 : Employability Skill** Equip with skills, based on current trends and future expectations for career development and placements. **PO8: Entrepreneurial Skill** To create efficient entrepreneurs by accelerating critical thinking, problem solving, decision making and leadership qualities to facilitate startups. **PO9: Research Related Skill** A sense of inquiry and capability for questioning, problem arising, synthesizing and articulating. Ability to recognize cause and effect relationships, define problems, formulate and test hypothesis, analyze, interpret and draw conclusions from data, establish hypothesis, predict cause and effect relationships, ability to plan, execute and report the results of an experiment or investigation. **PO10: Lifelong Learning** Identify the need for skills necessary to be successful in future, through self- paced and self - directed learning aiming at personal development, meeting economic, social and cultural objectives, adapting to changing trends and demands of work place. **PO11: Instrumentation Skill** Able to handle conventional and sophisticated instruments thereby acquiring employability skills. **PO12: Leadership Readiness and Qualities** Capability for building a team, identifying the tasks, setting direction, formulating an inspiring vision, employing skills to reach the right destination, smoothly.

	PO13: Information/ Digital Literacy Ability to use software for interpretation and analysis of data in a variety of learning situations. **PO14: Cooperation and Team Work** Ability to work effectively with diverse teams, facilitate cooperative or coordinated effort on the part of a group and act together as a group or as a team in the interest of a common cause and work efficiently as a member of a team.
Programme Specific Outcomes	**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.

Template for P.G., Programmes

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
Core-I General Microbiology and Microbial Diversity	5	7	. Core-IV Medical Bacteriol & Mycol	5	6	Core-VII Immunology & Microbial Genetics	5	6	Core-XI Food &Envi Mic Biol	5	6
Core-II Microbial Physiology	5	7	Core-V Medical Virolo & Parasitol	5	6	Core-VIII Mol Biol & r DNA Tech	5	6	Core-XII **PRACTICAL** **Applied Microbiol**	5	6
Core – III **PRACTICAL** General Microbiology and Microbial Diversity Microbial Physiology	4	6	Core – VI **PRACTICAL** **Medical Microbiol**	4	6	Core – IX **PRACTICAL** Immunology & Microbial Genetics Mol Biol & r DNA Tech	5	6	Project with viva voce	5	10
Elective -I Discipline Centric Forensic Science / Nano Biotechnology / Microalgal Technology	3	5	Elective – III Discipline Centric Epidemiology / Clinical Diagnostic Microbiol / Bioremediation	3	4	Core – X C1 Soil Microbiology & Microb Ecol C2 Microbial Toxicol C2 Water Conservation & Water Treatment	4	6	**Elective - VI** (Industry / Entrepreneurship) 20% Theory 80% Practical Bioenergy/ Marine Microbiol/ Life Science For Comp Exams	3	4
Elective-II Generic: Bioinstrumentaton / Herbal Technology / Cosmetic Microbiology / Essentials of Lab Mgmt & Biosafety	3	5	Elective -IV Generic: Bioinformatics / Biosafety, Bioethcis and IPR / Clinical Res & Clinical Trials	3	4	Elective - V Discipline Centric Fermentation Technology & Pharmaceutical Microbiology	3	3	Skill Enhancement course / Professional Competency Skill Research methodology & Biostat	2	4

			Skill Enhancement I Vermitechnology	2	4	3.6 Skill Enhancement II Organic Farming & Biofertiliser Technol	2	3	Extension Activity Microbial Quality Control & Testing	1	-
						3.7 Internship/ Industrial Activity	2	-			
	20	**30**		**22**	**30**		**26**	**30**		**21**	**30**
Total Credit Points -91											

Based Credits and Hours Distribution System

for all Post – Graduate Courses including Lab Hours

First Year – Semester – I

Part	List of Courses	Credits	No. of Hours
6	Core – I	5	7
	Core – II	5	7
	Core – III **PRACTICAL**	4	6
	Elective – I	3	5
	Elective – II	3	5
		20	**30**

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	5	6
	Core – V	5	6
	Core – VI **PRACTICAL**	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course [SEC] - I	2	4
		22	**30**

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX **PRACTICAL**	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity [Credits]	2	-
		26	**30**

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	5	6
	Core – XII **PRACTICAL**	5	6
	Project with VIVA VOCE	5	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		21	**30**

Total 91 Credits for PG Courses

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	
Remembering (K1)	• Thelowestlevelofquestionsrequirestudentstorecallinformationfromthecoursecontent • Knowledgequestionsusuallyrequirestudentstoidentifyinformationinthetextbook.
Understanding (K2)	• Understandingoffactsandideasbycomprehendingorganizing,comparing,translating,interpolatingandinterpretingintheirownwords. • Thequestionsgobeyondsimplerecallandrequirestudentstocombinedatatogether
Application (K3)	• Studentshavetosolveproblemsbyusing/applyingaconceptlearnedintheclassroom. • Studentsmust usetheir knowledgetodetermineaexactresponse.
Analyze (K4)	• Analyzingthequestionisonethatasksthestudentstobreakdownsomethingintoitscomponentparts. • Analyzingrequiresstudentstoidentifyreasonscausesormotivesandreachconclusionsorgeneralizations.
Evaluate (K5)	• Evaluationrequiresanindividualtomakejudgmentonsomething. • Questionstobeaskedtojudgethevalueofanidea,acharacter,aworkofart,orasolutiontoaproblem. • Studentsareengagedindecision-makingandproblem–solving. • Evaluationquestionsdonothavesinglerightanswers.
Create (K6)	• Thequestionsofthiscategorychallengestudentstogetengagedincreativeandoriginalthinking. • Developingoriginalideasandproblemsolvingskills

Credit Distribution for PG Courses
First Year
Semester-I

Course	Course Title	Credit	No. of Hours
Core-I	General Microbiology and Microbial Diversity	5	7
Core-II	Microbial Physiology	5	7
Core – III	Practical I – General Microbiology, Microbial Diversity and Microbial Physiology	4	6
Elective -I Discipline Centric	Forensic Science/ Nanobiotechnology/ Microalgal Technology (Among the three choices anyone can be chosen by the student)	3	5
Elective-II Generic:	Bioinstrumentation/ Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety (Among the three choices anyone can be chosen by the student)	3	5
	Total	**20**	**30**

First Year: Semester-II

Course	Course Title	Credit	No. of Hours
Core-IV	Medical Bacteriology and Mycology	5	6
Core-V	Medical Virology and Parasitology	5	6
Core – VI\	Practical II - Medical Microbiology	4	6
Elective – III Discipline Centric	Epidemiology/ Clinical Diagnostic Microbiology/ Bioremediation (Among the three choices anyone can be choosen by the student)	3	4
Elective -IV Generic:	Bioinformatics/ Biosafety, Bioethics and IPR / Clinical Research and Clinical Trials (Among the three choices anyone can be choosen by the student)	3	4
Skill Enhancement I	Vermitechnology	2	4
	Total	**22**	**30**

Second Year: Semester-III

Course	Course Title	Credit	No. of Hours
Core-VII	Immunology and Microbial Genetics	5	6
Core-VIII	Molecular Biology and Recombinant DNA Technology	5	6
Core – IX	Practical III - Immunology, Microbial Genetics and Molecular Biology	5	6
Core – X	Soil Microbiology and Microbial Ecology/ Microbial Toxicology/ Water Conservation and Water Treatment (Among the three choices anyone can be chosen by the student)	4	6
Elective – V Discipline Centric	Fermentation Technology and Pharmaceutical Microbiology	3	3
3.6 Skill Enhancement II	Organic Farming and Biofertiliser Technology	2	3
3.7 Internship/ Industrial Activity	Internship / Industrial Activity	2	-
	Total	**26**	**30**

Second Year: Semester-IV

Course	Course Title	Credit	No. of Hours
Core-XI	Food andEnvironmental Microbiology	5	6
Core-XII	Practical IV - Applied Microbiology	5	6
Project	Project with Viva Voce	7	10
Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	Bioenergy/ Marine Microbiology/ Life Science for Competitive Examinations (Among the three choices anyone can be chosen by the student)	3	4
Skill Enhancement course / Professional Competency Skill	Research Methodology and Biostatistics	2	4
Extension Activity	Microbial Quality Control and Testing	1	
		23	**30**

Credit Distribution for PG Course

S.No	Course Details	Credit
1	Core Course [12 Courses X 4 Credits]	48
2	Elective Course [6 Courses X 3 Credits]	18
3	Skill Enhancement Course [3 Courses X 2 Credits]	6
4A	Professional Competency Course & Industry Module	4
4B	Project Work VIVA VOCE	4
5	Ability Enhancement Compulsory Course [4 Courses X 2]	8
6	Internship	2
7	Extension Activity	1
		91

FIRST YEAR

FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	General Microbiology and Microbial Diversity	**Core Course I**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Acquire knowledge on the principles of different types of microscopes and their applications.
CO2	Explain various pure culture techniques and discuss sterilization methods.
CO3	Exemplify, isolate and cultivate microalgae from diverse environmental sources.
CO4	Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria.
CO5	Discuss the importance and conservation of microbial diversity.

UNIT	Details	No. of Hours	Course Objectives
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.	20	CO1
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.	15	CO4
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*, *VolvoxSpirogyra* (Green algae), *Nostoc* (Cyanobacteria) *Ectocarpus, Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae).	15	CO3
IV	BacterialStructure, properties and biosynthesis of cellular	20	CO2

	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.		
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.	20	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes.	PO1, PO4, PO11
CO2	Create aseptic conditions by following good laboratory practices.	PO1, PO4
CO3	Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance.	PO7, PO8, PO9
CO4	Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.	PO3, PO4,PO7
CO5	Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications.	PO5, PO7, PO8, PO9

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.
Web Resources	
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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M			M							S			
CO2	L			S										
CO3							S	S	M					
CO4			S	S			S							
CO5					S		S	S	S					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Microbial Physiology	**Core Course II**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Illustrate Bacterial nutrition and their utilization.
CO2	Discuss cultivation methods and factors related to microbial growth.
CO3	Demonstrate concepts of microbial metabolism.
CO4	Impart the fundamentals and importance of biosynthetic pathways.
CO5	Discuss the methods involved in Photosynthesis.

UNIT	Details	No. of Hours	Course Objectives
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..	20	CO1
II	Microbial growth – Growth curve and Measurement of Growth – Cell Number and Cell Mass and metabolic activity. Batch, Continuous, Synchronous and Asynchronous cultures, Factors affecting growth.	20	CO2
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 Transport chain, Mechanism of ATP synthesis – Chemiosmosis, Pasteur effect. Metabolism of lipids-β oxidation.	25	CO3
IV	Anaerobic Respiration. Nitrogen, Sulphur, Iron and Hydrogen Oxidation. Methanogenesis. Biosynthesis – Gluconeogenesis, Peptidoglycan synthesis, Amino acids, Purines, Pyrimidines Fattyacids, Triglycerides, Phospholipids and Sterols.	13	CO4
V	Photosynthesis – process, antenna of light-harvesting pigments, Photochemical reaction	12	CO5

	centers, Photosynthetic Electron Transport Chain-Cyclic and Non-cyclic. Oxygenic and Anoxygenic Photosynthesis. Calvin-Benson cycle. Bioluminescence - Process and application.		
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apply knowledge about nutritional requirement, modes of nutrient transport in microorganisms to various disciplines of Microbiology.	PO1, PO4, PO6, PO7, PO9
CO2	Analyse microbial growth, factors influencing growth and its measurement techniques for applications in various industries.	PO1, PO4, PO5,PO6, PO9
CO3	Compare various metabolic pathways and discuss the properties and functions of enzymes.	PO4, PO6, PO7, PO8, PO9, PO10
CO4	Apply anaerobic respiration and biosynthetic pathways to enhance/control microbial growth.	PO4,PO5, PO6, PO7, PO9, PO10
CO5	Assimilate methods involved in microbial photosynthesis and bioluminescence.	PO4,PO5, PO6, PO7, PO9, PO10

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.

References 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, New York.
5.	Rose, A.H. (1976). An Introduction to Microbial Physiology. 3rd Edn. Plenum, New York.
Web Resources	
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?journalCode=ibty20
4.	https://wew.sciencedirect.com/topics/neuroscience/microbial-respiration.
5.	https://www.britannica.com/science/photosynthesis.

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M		M	S		S					
CO2	S			S	M	S			S					
CO3				S		S	S	S	S	M				
CO4				S	M	S	M		S	M				
CO5				S	M	S	M		S	S				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Practical I – General Microbiology, Microbial Diversity and Microbial Physiology	**Core Course III-Practical I**	**-**	**-**	**Y**	**-**	**4**	**6**	**50**	**50**	**100**

Course Objectives

CO1	Gain knowledge on the fundamentals, handling and applications of microscopy,
CO2	Provide fundamental skills in sterilization methods. Identify microbes by different staining methods.
CO3	Prepare media for bacterial growth. Analyze microbial enzymes.
CO4	Perform plating techniques and methods involved in microbial preservation.
CO5	Measure bacterial growth, identify optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity.

UNIT	Details	No. of Hours	Course Objectives
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.	20	CO1
II	Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella.	20	CO2
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.	20	CO3
IV	Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer. Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate	10	CO4
V	Bacterial growth curve. Effect of physical and chemical	20	CO5

	factors on growth. Anaerobic culture methods.		
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Apply microscopic techniques and staining methods in the identification and differentiation of microbes.	PO1, PO6, PO7, PO8, PO9, PO11
CO2	Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth.	PO1, PO6, PO7, PO8, PO9, PO11
CO3	Prepare media for bacterial growth. Analyze microbial enzymes.	PO5, PO7, PO8, PO9, PO11
CO4	Pertain plating techniques and methods involved in microbial preservation.	PO6, PO7, PO8, PO9, PO11
CO5	Analyze microbial growth, optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity.	PO6, PO7, PO8, PO9, PO11

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, (6^{th} Edition). Pearson Education, Publication, New Delhi.
3.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2^{nd} Edition). - Taylor &Francis.
4.	Moat, A.G. Foster, J.W. and Spector, M. P (2002) Microbial Physiology, 4^{th} Edn. Wiley - Liss, New York.
5.	Dawes, I. W. and Sutherland, I. W (1992) Microbial physiology, 2^{nd} Edn. Black-well Scientific Publications, London.

References Books

1.	Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14^{th} Edition). Elsevier, New Delhi.
2.	Stanier R.Y., Ingraham, J.L., Wheelis, M.L and Painter, P.R. (2010). General Microbiology. 5th Edn. Macmilan education Ltd. London.
3.	Prescott. L.M., Harley. J.P., Klein. D.A. (1993). Microbiology. 2_{nd} edn. Wm. C. Brown publishers, Dubugue.
4.	Gottschalk, G. (1986). Bacterial Metabolism.2^{nd} Edn. Springer-Verlag, New York.
5.	Rose, A.H. (1976). An Introduction to Microbial Physiology. 3^{rd} Edn. Plenum, New York.

Web Resources

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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	40 Marks
	Attendance and Class Participation	
External Evaluation	End Semester Examination	60 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M					S	M	M	S		M			
CO2	M					S	M	M	S		M			
CO3					S		S	M	S		M			
CO4						S	S	M	S		S			
CO5						S	S	M	S		S			

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Forensic Science	**Elective Course I (Choice -1)**	**3**	**1**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Understand the Scope, need and learn the tools and techniques in forensic science.		
CO2	Comprehend organizational setup of a forensic science laboratory.		
CO3	Identify and Examine body fluids for identification.		
CO4	Extract DNA from blood samples for investigation.		
CO5	Recognize medico legal post mortem procedures and their importance.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Forensic Science - Definition, history and development of forensic 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.	12	CO1
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.	12	CO2
III	Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre.	12	CO3
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.	12	CO4
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.	12	CO5
	Total	60	
Course Outcomes	On completion of this course, students will;		
CO1	Identify the scope and need of forensic science in the present scenario.	PO1, PO6, PO7, PO8, PO9	
CO2	Plan for the organizational setup and functioning of forensic science laboratories.	PO1, PO6, PO7, PO8, PO9	
CO3	Analyze the biological samples found at the crime scene.	PO1, PO5, PO7, PO8, PO9	
CO4	Perform extraction and identification of DNA obtained from body fluids.	PO1, PO6, PO7, PO8, PO9	
CO5	Discuss the concept of forensic toxicology.	PO1, PO6, PO7, PO8, PO9	
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. (6th Edition)Universal Press.
5.	Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12th Edition).Pearson Press.
Reference books	
1.	Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3.
2.	Saferstein R. and Hall A. B. (2020). Forensic Science Hand book, Vol. I, (3rd Edition). CRC Press, New York. ISBN-10:1498720196.
3.	Lincoln, P.J. and Thomson, J. (1998). (2nd Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3.
4.	Val McDermid (2014). Forensics. (2nd Edition). ISBN 9780802125156.
5.	Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2nd Edition). CRC Press.
Web resources	
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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks

	Total	100 Marks

Methods of Assessment	
Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L					S	M	M	S					
CO2	M					S	M	M	S					
CO3	L				S		S	M	S					
CO4	M					S	S	M	S					
CO5	M					S	S	M	S					

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Nanobiotechnology	**Elective Course I (Choice 2)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Analyze nanomaterials based on the understanding of nanobiotechnology.
CO2	Discuss the methods of fabrication of nanomaterials.
CO3	Gain Knowledge on characterization of nanomaterials.
CO4	Discover nanomaterials for targeted drug delivery.
CO5	Explain nanomaterials in nanomedicine and environmental pollution.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
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.	12	CO1
II	Fabrication of Nanomaterials-Top-down and Bottom-up approaches, 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.	12	CO2
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	12	CO3

	optical properties- UV – Spectrophotometer, Based on magnetic properties-Vibrating sample magnetometer(VSM).		
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.	12	CO4
V	Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Employ knowledge in the field of nanobiotechnology for development.	PO1, PO9
CO2	Identify various applications of nanomaterials in the field of medicine and environment.	PO1, PO9
CO3	Examine the prospects and significance of nanobiotechnology.	PO1, PO6, PO11
CO4	Identify recent advances in this area and create a career or pursue research in the field.	PO1, PO5, PO7, PO9
CO5	Design non-toxic nanoparticles for targeted drug delivery.	PO1,PO5, PO7, PO9, PO11

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.

References Books

1.	Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley.
2.	Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd.
3.	Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience.

4.	Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press.
5..	Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press

Web Resources	
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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M					M					
CO2	S								S					

CO3	S					M					S			
CO4	S				S		M		S					
CO5	S				S		M		S		S			

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Microalgal Technology	**Elective Course I (Choice -3)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Characterize the different groups of algae.
CO2	Describe the cultivation and harvesting of algae.
CO3	Identify the commercial applications of various algal products.
CO4	Apply microalgae for environmental applications.
CO5	Employ microalgae as alternate fuels.

UNIT	Details	No. of Hours	Course Objectives
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.	12	CO1
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.	12	CO2
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.	12	CO3
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	12	CO4

	blooms, algicides for algal control.		
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.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Acquire knowledge in the field of microalgal technology and their characteristics.	PO1
CO2	Identify the methods of algal cultivation and harvesting.	PO1, PO6
CO3	Recognize and recommend the use of microalgae as food, feed and fodder.	PO7, PO8, PO9
CO4	Promote microalgae in phycoremediation.	PO7, PO9, PO11, PO14
CO5	Compare and critically evaluate recent applied research in these microalgal applications.	PO7, PO8, PO9

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.
References 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.
Web Resources	
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	
Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S													
CO2	S					M								
CO3							S	S	S					
CO4							S		S		M			M
CO5							M	S	S					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Bioinstrumentation	**Elective Course II (Choice -1)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Explain the principles and working mechanisms of laboratory instruments.
CO2	Discuss chromatography techniques and molecular biology techniques.
CO3	Illustrate molecular techniques in biological applications.
CO4	Acquire knowledge on spectroscopic techniques
CO5	Demonstrate the use of radio isotopes in various techniques.

UNIT	Details	No. of Hours	Course Objectives
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 - Applications in determination of molecular weight.	12	CO1
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).	12	CO2
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.	12	CO3
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	12	CO4

	biomolecules by Spectroscopy UV/visible.		
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.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP.	PO4, PO6, PO7, PO8, P11
CO2	Apply chromatography techniques in the separation of biomolecules.	PO4, PO6, PO7, PO8, P11
CO3	Perform molecular techniques like mutagenesis and their detection.	PO4, PO6, PO7, PO8, P11
CO4	Estimate molecules in biological samples by adopting UV spectroscopic techniques.	PO4, PO6, PO7, PO8, P11
CO5	Cultivate organisms anaerobically.	PO4, PO6, PO7, PO8, P11

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.

References 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.
Web Resources	
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.

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1				S		M	M	S			S			
CO2				S		M	M	S			S			
CO3				S		S	S	S			S			
CO4				S		M	S	S			S			

CO5				S		M	S	S			L			

ubject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Herbal Technology and Cosmetic Microbiology	**Elective Course II (Choice 2)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives	
CO1	Impart knowledge of Indian Medicinal Plants and their applications in microbiology.
CO2	Promote the technical skills involved in preparation of different types of plant extracts.
CO3	Explain methods to analyze the antimicrobial activity of medicinal plants.
CO4	Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.
CO5	Gain insight into pharmacopeial microbial assays and biosafety.

UNIT	Details	No. of Hours	Course Objectives
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.	12	CO1
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.	12	CO2
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.	12	CO3
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 practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.	12	CO4

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.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Identify the applications of Indian medicinal plants in treating diseases.	PO1, PO5
CO2	Identify and authenticate herbal plants.	PO6, PO7
CO3	Evaluate the antimicrobial activity of medicinal plants.	PO4, PO6, PO9
CO4	Describe the role of microorganisms and their metabolites in the preparation of cosmetics.	PO1, PO5, PO7
CO5	Validate procedures and biosafety measures in the mass production of cosmetics.	PO6, PO7

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.

References 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 and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2nd edition). Saujanya Books, Delhi.ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856.
4.	Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233.
5.	Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press.Totowa, NJ, USA. ISBN-10:1617371904.

Web Resources

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/

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S									
CO2						S	M							
CO3				S		S			M					
CO4	M				S		S							

CO5						M	S							

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Essentials of Laboratory Management and Biosafety	**Elective Course II (Choice 3)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives	
CO1	To utilize containment principles to ensure biosafety.
CO2	To enrich the student role and responsibilities of laboratory hazards and their control.
CO3	To know the importance of first aid technique for various common lab accidents.
CO4	To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory.
CO5	To discuss the biosafety regulations and guidelines and implementation of safety programs.

UNIT	Details	No. of Hours	Course Objectives
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.	12	CO1
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.	12	CO2
III	Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators.	12	CO3

	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.		
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.	12	CO4
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.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Employ skills on laboratory safety and avoid laboratory accidents.	PO1, PO2, PO3, PO7, PO11
CO2	Prevent laboratory hazards by practicing safety strategies.	PO2, PO5, PO7, PO11
CO3	Practice various first aid procedures during common laboratory accidents.	PO1, PO2, PO3, PO5, PO10, PO11
CO4	Ensure biosafety strategies in laboratory.	PO2, PO3, PO4, PO7, PO10, PO11
CO5	Recognize the importance of biosafety guidelines.	PO3, PO4, PO5, PO7, PO10, PO11

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. (1sr Edition). Notion Press. ISBN 10: 1645878856
3.	Biosafety in Microbiological and Biomedical Laboratories - U.S. Health Department and Human Services. (2016). (5^{th} Edition). Lulu.com.
4.	Kanai. L. Mukherjee. (Medical Laboratory Technology(4^{th} Edition). CBS Publishers.

5.	Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers.
References 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
Web Resources	
1.	https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-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-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf
5.	https://www.who.int/publications/i/item/9789240011311

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	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
Analyse (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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S	S				S				S			
CO2		S			S		S				S			
CO3	S	S	S		S					S	S			
CO4		S	S	M			S			S	S			
CO5			S	S	S		S			S	S			

FIRST YEAR
SEMESTER II

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Medical Bacteriology and Mycology	**Core Course IV**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens.
CO2	Explain morphology, characteristics and pathogenesis of bacteria.
CO3	Discuss various factors leading to pathogenesis of bacteria.
CO4	Acquire knowledge on antifungal agents and their importance.
CO5	Describe various diagnostic methods available for fungal disease diagnosis.

UNIT	Details	No. of Hours	Course Objectives
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.	20	CO1

II	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci, Neisseriae*., *Bacillus, Corynebacteria, Mycobacteria* and *Clostridium.*	20	CO2
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.	20	CO3
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.	15	CO4
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.	15	CO5
	Total	90	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Collect, transport and process of various kinds of clinical specimens.	PO1,PO5,PO9
CO2	Analyze various bacteria based on morphology and pathogenesis.	PO1,PO5,PO9
CO3	Discuss various treatment methods for bacterial disease.	PO1,PO5,PO9
CO4	Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents..	PO5,PO9
CO5	Apply various immunodiagnostic method to detect fungal infections.	PO5,PO9

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.
References 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. Pfaller. 7th edn. Elsevier, Mosby Saunders.
Web Resources	
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/

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S				M					
CO2	M				S				M					
CO3	M				S				M					
CO4					S				M					
CO5					S				M					

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Medical Virology and Parasitology	**Core Course V Theory**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives

CO1	Describe the replication strategy and cultivation methods of viruses.
CO2	Acquire knowledge about oncogenic virus and human viral infections.
CO3	Develop diagnostic skills, in the identification of virus infections.
CO4	Impart knowledge about parasitic infections.
CO5	Develop diagnostic skills, in the identification of parasitic infections.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation	20	CO1

	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).		
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 – Dengue virus, Ebola virus, Emerging and reemerging viral infections	20	CO2
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.	15	CO3
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.*	15	CO4
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.	20	CO5
	Total	90	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay.	PO5, PO7, PO8, PO10
CO2	Investigate the symptoms of viral infections and presumptively identify the viral disease.	PO5, PO7, PO8, PO10

CO3	Diagnose various viral diseases by different methods.(serological, conventional and molecular)	PO5, PO7, PO8, PO10
CO4	Educate public about the spread, control and prevention of parasitic diseases.	PO5, PO7, PO8, PO10
CO5	Identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections.	PO5, PO7, PO8, PO10

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's Microbiology. (11th Edition). McGraw Hill Book.
3.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
4.	Finegold S.M. (2000). Diagnostic Microbiology. (10th Edition). C.V. Mosby Company, St. Louis.
5.	Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6th Edition). S.A. Davies Co. Philadelphia.

Web Resources	
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

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	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
Analyses (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

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1					M		L	L		M				
CO2					M		L	L		M				
CO3					M		L	L		M				
CO4					M		L	L		M				
CO5					M		L	L		M				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Practical II - Medical Microbiology	**Core Course VI- Practica II**	**-**	**-**	**Y**	**-**	**4**	**6**	**50**	**50**	**100**

Course Objectives	
CO1	Develop skills in the diagnosis of bacterial infections and antimicrobial sensitivity.
CO2	Impart knowledge on fungal infections and its diagnosis.
CO3	Cultivation, identification and assay of viruses for diagnostics and vaccine production
CO4	Diagnose parasitic infections.
CO5	Identification of medically important vectors.

UNIT	Details	No. of Hours	Course Objectives
I	Staining of clinical specimens - Wet mount, Differential	20	CO1

	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.		
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.	20	CO2
III	Isolation and characterization of bacteriophage from natural sources by phage titration. Cultivation of viruses –Egg Inoculation methods. Diagnosis of Viral Infections –ELISA –HIA. Spotters of viral inclusions and CPE-stained smears.	20	CO3
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.	15	CO4
V	Identification of common arthropods of medical importance - spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites.	15	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Collection of different clinical samples, transport, culture and examination.	PO7, PO8, PO9

CO2	Identify medically important fungus from the clinical samples.	PO7, PO8, PO9
CO3	Perform and Interpret serological tests for viral diseases.	PO7, PO8, PO9, PO10
CO4	Exam and identify ova and cyst in samples.	PO7, PO8, PO9, PO10
CO5	Collection and identification of arthropod vectors.	PO7, PO8, PO9

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.
References 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.	Chart H. (2018). Practical Laboratory Bacteriology. CRC Press.
3.	Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd.
4.	.Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22nd Edition.Cambridge University Press.
5.	Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th Edition. Elsevier, Mosby Saunders
Web Resources	
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

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	

	Attendance and Class Participitation	
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
Analyse (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

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1							M	M	M					
CO2							M	M	M					
CO3							M	M	L	L				
CO4							M	M	M	L				
CO5							M	M	M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Epidemiology	**Elective Course III (Choice 1)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Describe the role of epidemiology in public health.
CO2	Explain about epidemiology tools and disease surveillance methods.
CO3	Analyze various communicable and non-communicable diseases in India.
CO4	Discuss on mechanism of antimicrobial resistance.
CO5	Outline on National health programmes that have been designed to address the issues.

UNIT	Details	No. of Hours	Course Objectives
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.	12	CO1
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	12	CO2

	investigation in public health and contact investigation.		
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.	12	CO3
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.	12	CO4
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.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Apply the knowledge acquired on concepts of epidemiology to clinical and public health environment.	PO1
CO2	Plan various strategies to trace the epidemiology.	PO4, PO5, PO6
CO3	Plan the control of communicable and non-communicable diseases.	PO1, PO5,
CO4	Analyze the implications of drug resistance in the society and	PO5,

	design the control of antimicrobial resistance and its management.	
CO5	Employ National control programs related to Communicable and Non-Communicable diseases with the public.	PO4, PO5,

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.
References Books	
1.	Bhopal R. S. (2016).Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3rd Edition). Oxford University Press, New York.
2.	Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6th Edition). 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.
Web Resources	
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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment		
Recall (KI)	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	

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M													
CO2				L	L	S								
CO3	M				S									
CO4					S									
CO5				S	S									

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Clinical and Diagnostic Microbiology	**Elective Course III (Choice 2)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**
Course Objectives											

CO1	Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management.		
CO2	Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab.		
CO3	Elucidate various diagnostic procedures in microbiology.		
CO4	Acquire knowledge on different methods employed to check antibiotic sensitivity.		
CO5	Gain knowledge on hospital acquired infections and their control measures.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
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.	12	CO1
II	Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.	12	CO2
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.	12	CO3
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.	12	CO4
V	Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.	12	CO5
	Total	60	
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Apply Laboratory safety procedures and hospital waste disposal strategies.		PO5, PO6, PO7
CO2	Collect various clinical specimens, handle, preserve and process safely.		PO6, PO7
CO3	Identify the causative agents of diseases by conventional and molecular methods following standard protocols.		PO6, PO7, PO9, PO11
CO4	Assess the antimicrobial susceptibility pattern of pathogens.		PO7, PO9

CO5	Trace the sources of nosocomial infection and recommend control measures.	PO5, PO7
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. (15thEdition). 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. (6thEdition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496.	
References 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 & Bartlett Learning. 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.	
Web Resources		
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	
Methods of Evaluation		
	Continuous Internal Assessment Tests	

Internal Evaluation	Assignments	25 Marks
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
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Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1					S	M	M							
CO2						M	S							
CO3						M	S		M		S			
CO4							S		M					
CO5					S		M							

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Bioremediation	**Elective Course III (Choice 3)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives			
CO1	Describe the nature and importance of bioremediation and use in real world applications.		
CO2	Describe the typical composition of waste water and application of efficient technologies for water treatment.		
CO3	Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.		
CO4	Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.		
CO5	Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
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. Recent developments and significance.	12	CO1
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.	12	CO2
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.	12	CO3
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.	12	CO4
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	12	CO5

	contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.		
	Total	60	
Course Outcomes			
Course Outcomes			
CO1	Differentiate Ex-situ bioremediation and In-situ bioremediation. Assess the roles of organisms in bioremediation.	PO1, PO2, PO4, PO5	
CO2	Distinguish microbial processes necessary for the design and optimization of biological processing unit operations.	PO1, PO4, PO5, PO11	
CO3	Identify, formulate and design engineered solutions to environmental problems.	PO5, PO7, PO8, PO11	
CO4	Explore microbes in degradation of toxic wastes and playing role on biological mechanisms.	PO5, PO6, PO7, PO8, PO9	
CO5	Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting *Rhizobacteria* in phytoremediation.	PO1, PO5, PO6, PO7, PO8	
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). WasteManagementPractices:Municipal,Hazardous,andIndustrial,2nd edition, CRC Press.		
4.	Liu,D.H.FandLiptak,B.G(2005).HazardousWastesandSolidWastes,Lewis Publishers. .		
5.	Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1st edition. MJP Publishers		
References 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. 1st		

	edition. I.K. International Publishing House Pvt. Ltd.
Web Resources	
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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
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Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	M		M	S									

CO2	S			M	S						S			
CO3					S		S	S			S			
CO4					S	S	S	S	S					
CO5	M				S	M	S	S						

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Bioinformatics	**Elective Course IV**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

		Theory (Choice 1)									

Course Objectives	
CO1	Discuss about various biological data mining concepts, tools.
CO2	Elucidate the principles and applications of sequence alignment methods and tools.
CO3	Demonstrate different phylogenetic tree construction methods and its uses in phylogenetic analysis.
CO4	Acquaint with various approaches in predicting 3D and 2D structure of proteins.
CO5	Describe various tools and techniques used in molecular docking, immunoinformatics and subtractive genomics.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
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).	12	CO1
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.	12	CO2
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.	12	CO3
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	12	CO4
V	Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic,	12	CO5

	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.		
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Access to databases that provides information on nucleic acids and proteins.	PO1, PO4, PO6, PO7, PO9, PO10, PO13
CO2	Invent algorithms for sequence alignment.	PO7, PO9, PO10, PO13
CO3	Construct phylogenetic tree.	PO6, PO9, PO10
CO4	Predict the structure of proteins.	PO4, PO6, PO7, PO9, PO13
CO5	Design drugs by predicting drug ligand interactions and molecular docking.	PO4, PO5, PO6, PO7, PO9, PO10, PO13

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.CBS Publishers, New Delhi.

References 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, Tata McGraw-Hill Publishing Company Limited.

Web Resources	
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

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
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Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M			M		M			M	M			M	
CO2							S		S	S			S	
CO3						S			S	S				
CO4				S		S	S		S				S	
CO5				S	S	S	S		S	S			S	

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Biosafety, Bioethics and IPR	**Elective Course IV (Choice 2)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Create a research environment. Encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine.
CO2	Discuss about various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products.
CO3	Familiarize fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries.
CO4	Acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops
CO5	Provide students with an understanding of bioethics in research associated with medicine

UNIT	Details	No.of Hours	Course Objectives
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.	12	CO1
II	Process involved in patenting. Patent Search - Procedural steps in patenting, process of filing, PCT application, pre-grant & post-grant opposition, PCT and patent harmonization including Sui-generis system, patent search methods, patent databases and libraries, online tools, Country-wise patent searches (USPTO, EPO, India etc.), patent mapping.	12	CO2

III	Patentability of biotechnology inventions - Patentability of biotechnology inventions in India, statutory provisions regarding 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.	12	CO3
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.	12	CO4
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 and hopes. 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.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Execute the role of IPR, Patent, Trademarks and its importance.	PO1, PO2, PO3, PO5, PO6
CO2	Develop patent procedure, patent filling and its mapping.	PO3, PO4, PO13
CO3	Become Patent attorneys and Patent officers.	PO2, PO3, PO4, PO7, PO9
CO4	Applybioethics in GMO, food crops and its biodiversity.	PO2, PO3, PO5, PO9
CO5	Analyze the importance of bioethics in research	PO1, PO3, PO5, PO6,

	associated with HGP, clinical research, stem cell therapy.	PO9, PO10
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, Biosaftey and Bioethics. (1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700	
4.	Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications.	
5.	Sibi. GIntellectual, Property Rights, Bioethics, Biosafety and Entreepreneurship in biotechnology. (2021). Wiley Publications.	
References 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: Lexis Nexis.	
4.	Tony Hope (2004). Medical Ethics: A very Short introduction,. Oxford Publication.	
5.	Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications.	
Web Resources		
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	
Methods of Evaluation		

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
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Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S	S		S	S								
CO2			S	S									M	
CO3		S	S	S			S		S					
CO4		S	S		S				S					
CO5	S		S		S	S			S	M				

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Clinical	**Elective**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

	Research And Clinical Trials	Course IV (Choice 3)									

Course Objectives			
CO1	Provide an overview of history and methods involved in conducting clinical research.		
CO2	Design the principles involved in ethical, legal, and regulatory issues in clinical research on human subjects.		
CO3	Describe principles and issues involved in monitoring patient-oriented research.		
CO4	Formulate a well- defined quality assurance and quality control plans.		
CO5	Acquire business development skills in the area of clinical research.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
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).	12	CO1
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.	12	CO2
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.	12	CO3
IV	Quality Assurance, Quality Control & Clinical Monitoring: Defining the terminology-Quality, Quality system, Quality	12	CO4

	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.		
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.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apprehend the Drug Development process and different phases of clinical trials.	PO1, PO2, PO3, PO5
CO2	Recognize the ethics and regulatory perspectives on clinical research trials activities.	PO3, PO5, PO6, PO9
CO3	Accentuate about clinical trials management concepts and documentation process.	PO2, PO4, PO6, PO9
CO4	Accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trial results.	PO2, PO4. PO6. PO7, PO9
CO5	To nurture skills recitation to commercial start up and industriousness.	PO4, PO8, PO9, PO11, PO13

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.
References 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, 2ndEdition 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. 2ndEdition, CRC press, Taylor and Francis Group.
Web Resources	
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

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	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.
Analyse (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.

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S	S		S									
CO2			S		S	S			S					
CO3		S		S		S			S					
CO4		S		S		S	S		S					
CO5				S				S	S		S		M	

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
	Vermitechnology	**Skill Enhancement Course 1**	**Y**	**-**	**-**	**-**	**2**	**2**	**25**	**75**	**100**

Course Objectives	
CO1	Introduce the concepts of vermicomposting.
CO2	Explain the physiology, anatomy and biology of earthworms.
CO3	Acquire the knowledge of the vermicomposting process.
CO4	Explain the trouble shooting, harvesting and packaging of vermin composts.
CO5	Gain knowledge on applications of vermin composts and their value added products.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
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.	6	CO1
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,	6	CO2

	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).		
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.	6	CO3
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.	6	CO4
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.	6	CO5
	Total	30	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Compare and contrast the uses of vermicompost to the soil.	PO1, PO4, PO5, PO9,
CO2	Recommend different species of earthworms after acquiring knowledge on its biology.	PO1, PO4, PO6, PO9
CO3	Design the vermicomposting process.	PO1, PO4, PO6, PO7, PO8
CO4	Assess the Best Practices of Vermicomposting	PO6,PO7, PO8,PO9,
CO5	Recommend the applications of vermicompost to different soils and for different crops.	PO1, PO4, PO5,PO6, PO7

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.
References Books	
1	Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing.
2	Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi.
3	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.
Web Resources	
1.	https://en.wikipedia.org/wiki/Vermicompost
2.	http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf
3.	https://www.kngac.ac.in/elearning-portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf
4.	https://composting.ces.ncsu.edu/vermicomposting-2/
5.	https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/

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Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M	S				S					
CO2	S			M		S			S					
CO3	S			S		S	S	S						
CO4						S	S	S	S					
CO5	S			M	S	M	S							

******END OF FIRST YEAR (FIRST AND SECOND SEMESTER)*******